University of Alberta

Assessing and Predicting
Information and Communication Technology Literacy
in Education Undergraduates

by

JoAnne E. Davies

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A thesis submitted to the Faculty of Graduate Studies and Research
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ABSTRACT

In recent years, the view that Information and Communication Technology (ICT) is vital in K-12 education has become widespread. ICT use in schools has increased and various professional bodies have set ICT standards for students and teachers. Questions abound as to whether teachers have the skills that their students are expected to attain. Schools of education are under pressure to produce teachers who are able to effectively integrate technology into their teaching. However, most teacher preparation programs do not adequately prepare teachers in ICT, nor assess candidates relative to ICT standards.

The objectives of this study were: (1) to develop a computerized system that assesses ICT declarative and procedural knowledge and provides a profile to the participant, (2) to gather baseline information on the ICT literacy of undergraduate Education students, and (3) to determine whether there are characteristics associated with students with greater ICT expertise.

This study tested 713 undergraduate students at the start of an educational technology course and found generally weak ICT literacy. This implies that teacher education programs should continue to take measures to increase the computer technical competency of students, as part of preparing pre-service teachers to teach with technology. A multiple regression analysis revealed that ICT literacy can be positively predicted by: variety of previous computer experience, amount of post-secondary computer-related studies, amount of ICT exposure in K-12 schooling (higher for more recent high school graduates), ownership of a home computer, general academic ability, gender (male), and computer self-efficacy.

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CHAPTER I: INTRODUCTION

Background

Technology can be defined as "the practical application of knowledge, especially in a particular area" or "a manner of accomplishing a task, especially using technical processes, methods, or knowledge" (Merriam-Webster, 1999). Information and Communication Technology (ICT) specifically refers to "devices and systems that are used in processing, transferring and storing information and in communicating through electronic media" (Alberta Education, 1998, p. 4). Computer hardware, software, networks, and related processes, techniques and knowledge are elements of ICT. These technologies pervade most aspects of contemporary civilization and will undoubtedly influence our future world to an even greater extent (Robertson, 1998; Tapscott, 1997), "enabling us to live, work and think in ways that most of us never dreamed were possible" (Alberta Education, 1998, p. 1).

The term ICT is usually synonymous with the shorter term "Information Technology," however this study will be based on the term ICT to retain a special emphasis on the word "Communication" because the Internet/World Wide Web (WWW) are important aspects of the skills and knowledge examined. It should also be noted that there are special terms often used to refer specifically to the use of technology in education such as educational computing, educational technology or instructional technology. The latter is actually a more general term that can be defined as "the theory and practice of design, development, utilization, management and evaluation of processes and resources for learning" (Seels & Richey, 1994, p.1) and may or may not involve the use of computers or networks. Since the skills and knowledge tested in this study are computer/network specific and could apply to situations outside of education, the non-education specific term ICT is more appropriate for this study.

Over the past few years, governments, education organizations, and researchers have increasingly supported the view that incorporating ICT into learning and teaching is an important aspect of keeping the curriculum relevant and preparing students for their future in a complex knowledge-based world (Alberta Education, 1999b; CEO Forum on Education and Technology, 1997; Jonassen, 1995; Logan, 1995; Milken Exchange on

Educational Technology, 1999c; Thornburg, 1991). "Technology should be viewed by educators as a major area for study since it is one of the principal factors determining how people experience and know their world" (Fanning, 1996).

An indication of the increasing attention paid to technology in education is that ICT-related standards for students and teachers have recently been developed by various educational organizations. Supported by the U.S. Department of Education, the International Society for Technology in Education (ISTE, 1998) has published *National Educational Technology Standards for Students* (NETS); these standards cover grades PreK – 12. *National Standards for Technology in Teacher Preparation* contain recommendations to the U. S. National Council for Accreditation of Teacher Education concerning foundations in technology for all teachers (ISTE, 1997). *Information and Communication Technology, Kindergarten to Grade 12* (Alberta Learning, 2000), describes the mandated Alberta program of ICT studies. This program stresses that ICT should be learned in context, addressing real-life problems, and thus is structured not as a standalone curriculum, but a curriculum embedded within other curricula, particularly the core subjects English, Math, Science and Social Studies.

Most schools of education have been grappling with the issue of how to better prepare teachers to effectively integrate technology into their teaching and have undertaken restructuring processes including computing infrastructure enhancements, faculty professional development initiatives, and revised course offerings (Bielefeldt, 2001; DeWert, 2000; Milken Exchange on Educational Technology & International Society for Technology in Education, 1999; U.S. Congress - Office of Technology Assessment, 1995). Over the past few years, the author has been involved in the development and delivery of an educational technology course at a major Canadian research university that, at the time of this writing, serves about 1000 students per year. This course is recommended for satisfying the 3-credit computing requirement for Bachelor of Education (B. Ed.) students (although students can elect to take alternative courses such as computing science, offered by the Faculty of Science).

Ultimately, the emphasis in programs preparing new teachers should be on "teaching with technology across the curriculum" rather than "teaching about technology as a separate subject" (Brush et al., 2001; President's Committee of Advisors on Science and Technology, 1997; U.S. Congress - Office of Technology Assessment, 1995). However, based on informal observations the author has gathered while teaching undergraduate educational technology courses, it appears that many pre-service teachers begin post-secondary studies with inadequate basic computer literacy, making this goal more difficult to attain at this time. The educational technology course the author has been involved with is primarily a software tools course, although it does take some initial steps toward an understanding of integrating technology into the K-12 curriculum (e.g., students are asked to complete curriculum-relevant projects using productivity software and explain how these would be integrated into K-12 learning activities). Many students appear to be so overwhelmed with the task of just attaining a basic understanding of the use of computer tools that it is difficult to focus much course time on learning how to teach with the tools.

For the past few years there has been discussion within the faculty as to whether such a course should continue to be offered. For example, during a massive faculty re-organization that took place in the mid-1990s, the B. Ed. computing requirement was reduced from one 3-credit course to a 1.5 credit course. Subsequently, that action was reversed. The current course demands significant resources - many hours of lab assistant and marking time, as well as heavy demands on computer labs. Will the faculty be able to assume in the near future that the majority of incoming education students will possess adequate ICT literacy, making this course either unnecessary or in need of revision? This assumption would be based on the fact that mandated "technology outcomes" are being phased into the Provincial K-12 curriculum (Alberta Learning, 2000) from 2000 to 2003, which could possibly mean that most high school graduates would then be entering post-secondary studies with adequate ICT literacy. Perhaps any students who are still deficient in ICT skills should obtain these skills on their own, prior to being accepted into the faculty? Should students be routed into different courses or take individual pathways through courses based on their level of ICT literacy? Should the "computing requirement" only be satisfied by courses that concentrate on curriculum integration, courses that assume basic ICT operating skills and experience with a wide variety of software tools? If this is the case, the faculty needs to be aware of the ICT skill level of students and put mechanisms in place to provide assistance with the technical aspects of learning to use computer tools. Experience has shown that novice computer users often need a lot of one-on-one help; they certainly can't all be left to just "learn it on their own." Should the course-based computing requirement be removed in favor of a broader approach in which technology skills are imparted throughout the teacher education program? Many of these questions in turn raise the issue of whether faculty are prepared to incorporate technology into the content of their courses or model technology application in the delivery of their courses or in their administrative and research activities. (DeWert, 2000; Milken Exchange on Educational Technology & International Society for Technology in Education, 1999).

Whatever the approach taken, it is important that the faculty produce teachers with an understanding of appropriate educational use of ICT, along with underlying basic technical competency. Teachers should be independent computer users, able to troubleshoot through routine problems on their own. Teachers should also be capable of exploring ICT tools without always depending on a formal training session or a technical expert to explain how things work; learning new aspects of ICT is obviously easier when one has a foundation of existing experiences and knowledge. Some professional development opportunities should be available in schools, but teachers should also be capable of using manuals or online help facilities to learn new ICT concepts. Teachers must have ICT literacy exceeding what students are expected to have, for example (from the Provincial technology outcomes): troubleshooting technical problems, loading software, connecting and operating peripheral equipment, managing data and personal files, and applying safety procedures such as disk scans or virus checks (Alberta Learning, 2000). In order to optimize use of technology, both teachers and students must be adept users (Bracewell, Breuleux, Laferrière, Benoit, & Abdous, 1998; Réginald Grégoire inc., Bracewell, & Laferrière, 1996). However, when they enter the teaching world, beginning teachers should find that technical support is available in schools for more complex or time-consuming concerns such as hardware maintenance, major software installation/upgrading, and managing networks.

Data that provide insight into the computer literacy level of incoming undergraduate education students would be helpful to faculty attempting to resolve the types of questions that are facing the schools of education. However, there is currently no assessment tool deemed appropriate for this purpose or information available that indicates the ICT literacy level of current or prospective students. The predictive validity of a high school transcript or grade 12 English or mathematics marks is insufficient. Are we are yet at the point where we can say that, for the majority of students, a high school diploma implies adequate ICT experiences? It is difficult to forecast if and when this might become true - some colleagues are informally predicting that it is still very far away while others believe it has already occurred or will soon occur. How do the ICT skills of recent undergraduate students compare with the skills indicated at the Grade 12 level of the Provincial technology outcomes? Although the Best Practices in Technology documents (Alberta Education, 1999a) indicate that much ICT-related activity is occurring in schools, and an optional ICT K-12 curriculum has been available since June 1998, there are currently a few students entering educational technology courses at this university who have literally never turned on a computer (based on an informal "hands-up" survey of students in September 1999). Many students appear to be familiar with some aspects of ICT, and a few are quite adept. Thus, ICT experiences and outcomes (whether school or non-school) appear to vary across a wide range of knowledge and skill levels.

It would also be useful (for all involved in K-12 or post-secondary education) to understand what characteristics are associated with students beginning post-secondary studies with a stronger ICT background. Characteristics such as gender, general academic ability, self-efficacy/attitude toward computers, level of previous ICT exposure (at school, home or work), and socio-economic status are possible predictors of ICT expertise that will be explored in this study.

Problem Statement

The first problem investigated in this study was to describe the level of ICT Literacy of a typical group of undergraduate education students (as early as possible in their post-secondary studies) in order to understand to what extent such students need to have computer technical competencies developed within their teacher education programs. The second problem was to explore the impact on ICT literacy of a typical computer technical skills post-secondary course. A third problem investigated was to gain insight into individual differences in ICT literacy, that is, identifying student characteristics associated with higher ICT expertise. In order to examine these questions, this study also addressed the preliminary problem of developing appropriate instruments for gathering data on student characteristics and assessing ICT declarative and procedural knowledge.

Research Hypotheses

In this study, three sets of hypotheses were examined. The first set of hypotheses concerned assessing ICT literacy – testing whether the group of students tested had generally high or low ICT pre-scores (by comparing with an assumed mastery threshold), and whether students displayed significant improvement from pre to post-test, after taking a computer skills course. The second set of hypotheses concerned predicting ICT literacy – testing whether a model could be developed to predict ICT pre-scores, identifying a minimal set of variables associated with individual differences in ICT scores, determining the relative strength of the predictors, and determining whether each predictor impacted ICT scores negatively or positively. The third set of hypotheses concerned trends in ICT use in schools – since this study included participants who graduated high school in a wide range of years, it was possible to test whether more recent graduates had experienced greater exposure to ICT in their K-12 schooling, specifically with regard to the earliest grade in which they started using computers and how many high school subjects used ICT. The research hypotheses are listed below:

Assessing ICT Literacy

1. The mean pre-test scores on both ICT Knowledge and ICT Performance will be significantly lower than 80% (an assumed mastery level).

2. The mean post-test scores on both ICT Knowledge and ICT Performance will be significantly higher than the corresponding pre-test scores.

Predicting ICT Literacy

3. Pre-test ICT Literacy (and Knowledge and Performance sub-scores) can be significantly predicted by some linear combination of one or more of the variables examined in this study.
4. The following categorical variable values will contribute positively in the prediction of pre-test ICT Literacy (and Knowledge and Performance sub-scores): (a) Gender = Male, (b) Home Computer = Yes, (c) Other Access to Computer (workplace/other household) = Yes, (d) Urban/Rural High School = Urban, (e) Post-Secondary Experience = After-Degree/Fifth year or more, (f) Program Route not = Elementary Education, (g) Program Focus = Science/Math/Technology related, (h) Previous Post-Secondary Credit Computer Course = Yes, and (i) Previous Non-Credit Computer Course/Workshop = Yes.
5. The following quantitative variables will contribute positively in the prediction of pre-test ICT Literacy (and Knowledge and Performance sub-scores), that is, higher values of the variables will be associated with higher values in ICT Literacy: (a) SES – Parents' Highest Education, (b) Years of Computer Use in K-12 School, (c) Number of High School Subjects that used ICT, (d) Year of High School Graduation, (e) General Academic Ability, (f) Years of Computer Use, (g) Variety of Computer Experience - number of software applications used, (h) Computer Self-Efficacy, and (i) Attitude Toward Computers in Society/Education.

Trends in ICT Use in Schools

6. Recent high school graduates started ICT use in school in earlier grades than those who graduated longer ago.
7. Recent high school graduates had ICT integrated into more high school courses than those who graduated longer ago.

Significance of the Study

By enabling early identification of ICT weaknesses of early post-secondary students, this research should provide helpful data to persons involved in either delivering K-12 school programs or in evaluating student achievement of technology standards. Professional development programs for education faculty could also benefit from this knowledge. Since pre-service K-12 teachers should possess ICT skills exceeding those of their future students, this also applies to the university faculty who teach these pre-service teachers. Faculty members should be aware of undergraduate ICT weaknesses and be capable of directing students to higher levels of ICT expertise.

This study also resulted in the development of an online ICT literacy assessment system that provides information to participants regarding their overall ICT knowledge and ICT skills, as well as specific areas of strength and weakness. This system could be adapted for use in other situations to enable student self-direction, individualization within courses, and improved program planning. By gathering a baseline assessment of the entry ICT knowledge and skills that undergraduate education students possess, this research has also provided greater insight to the question, "Whom are we teaching?" This new insight may in turn contribute to improving B.Ed. programs, particularly their coverage of ICT. This study has specifically generated data that will be useful in reassessing the need and strategies for delivering computer productivity tools instruction, which are important considerations in the design of either ICT-specific courses or other education courses that incorporate ICT. This instrument and data would have been valuable in course development projects in which the author and colleagues have been involved over the past few years; instructors could have been better prepared to work with the unexpected numbers of inexperienced computer users.

Limitations

The first limitation of the study was that an experimental design could not be used due to the nature of the predictor variables. These variables were largely historical or impossible/unethical to manipulate. Instead, this study used a correlational/ex post facto design and investigated certain variables in retrospect. Results using this non-experimental method were interpreted with caution; they do not prove (they only suggest) cause and effect (Fraenkel & Wallen, 1996).

A second limitation was that the participants were students attending a particular university, and the participants were selected (screened) based on the specific entrance requirements of that university. Also, 49% of the participants graduated from a high school in or near the city in which the university is located and 79% of the participants were from the same province. Thus, the results of this study may not reflect the characteristics of students from other geographic areas.

A third limitation was that the sample of students used in this study, although large, must be viewed as a "convenience sample." Students who were difficult to access were excluded from the study and the researcher had no practical way of knowing whether such students were markedly different (either higher or lower) in their ICT skills. Ideally, this study should have tested (immediately upon their entrance to post-secondary studies) the ICT literacy level of all undergraduate students intending to pursue a B. Ed. degree at this university (or at least a suitable random sample of such students). This would have provided a clearer picture of what they "arrive at university with" and thus also an indication of what must be done during their studies to assist them in reaching an adequate level of ICT literacy. However, at this institution, pre-service teachers are not admitted to the Faculty of Education throughout their degree program; typically they spend one or more years registered in other faculties, universities or colleges before transferring to this Faculty of Education. The basic B. Ed. Program of studies at this university is a "1 + 3" program in which students first take a year of preparatory university studies (in another faculty such as Arts or Science) before they can apply for admission to the Faculty of Education to complete the final three years of their studies. It would have been logistically difficult to contact prospective education students at the time of their admission to the university to schedule a time for testing. That approach would have required a significant amount of advance planning and cooperation with the registrar's office in order to determine which students to contact and how to contact them; such a process could have delayed this study by several months. Also, scheduling computer lab time in an appropriate facility for administering the tests may have been difficult and may have resulted in inconvenient times for students, given that many of the university's computer labs are fully booked during normal weekday hours. The researcher was not optimistic about getting a high response level and an unbiased sample using such an approach. If students just starting university were somehow informed that an educational researcher was inviting them to contact her to make an appointment (for likely an evening or weekend time) to have their computer literacy tested how many would have responded? Likely just a handful of students who felt some particular interest in ICT literacy, that is, a potentially very biased sample.

There are also other variations in B. Ed. programs that complicate access to participants. One variation is the "transfer students" who first take two years at a cooperating institution (usually including an educational technology course) and transfer to this university for the final two years of their programs. Another complication is the "combined degree" programs in which students spend two or three years registered in another faculty before switching to the Faculty of Education to complete the final part of their degrees. "After Degree" students are another special case – they have already completed an undergraduate degree (and possibly their computing option) prior to entering education studies. In order to simplify access to potential participants and to increase the probability of a high response rate, this study targeted students enrolled in two educational technology courses offered through the Faculty of Education. Additional details concerning this third limitation are discussed in the Research Methods/Participants section.

Delimitations

This study was restricted to examining education or prospective education students studying at the undergraduate level at one large Canadian university; graduate students were excluded. Another delimitation was that the computer literacy tests developed for this study were restricted to examining basic procedural and declarative skills relative to the most common processes for productivity described in the provincial K-12 ICT curriculum (Alberta Learning, 2000): computer operation, file management, word processing, Internet-based communications, digital media, spreadsheets and databases; they exclude more advanced skills such as computer programming, network management, or computer hardware design. Furthermore, the tests did not contain items specific to the educational use of computers; they were equally relevant to testing basic ICT literacy in a non-education setting.

Definition of Terms

Attitude: a predisposition to respond in a particular way concerning a given topic. In this study, participant feelings of self-efficacy towards using computers and attitudes toward the use of computer technology in education and society in general were measured using the ICT Literacy - Computer Attitudes Survey, a 20-item Likert-type scale.

Declarative Knowledge: knowledge that is measured via an assessment tool similar to traditional paper-and-pencil methods (e.g., multiple-choice exam). In this study, ICT Declarative Knowledge (understanding of computer-related terminology and concepts) was measured using the ICT Literacy - Knowledge Test, a 28-item multiple-choice test.

General Academic Ability: an individual's performance level in formal educational situations. This ability was measured in this study as the student's previous university Grade Point Average (GPA) upon admission to the Faculty of Education. This value was calculated as the average grade on the most recent 30 credits of post-secondary work prior to admission to Education and was obtained from the university student database.

HTML: HyperText Markup Language; the most common command language used to create hypermedia documents (which may include text, images, video or sound) for display on the World Wide Web.

ICT: Information and Communication Technology; devices and systems that are used in processing, transferring and storing information and in communicating through electronic media (Alberta Education, 1998).

ICT Literacy: The skills listed in the provincial ICT curriculum (Alberta Learning, 2000) provided a conceptual definition of ICT Literacy. In this study, ICT Literacy was operationalized as the mean of standardized scores from the ICT Knowledge and Performance tests that measured declarative and procedural knowledge about ICT.

Internet: an electronic communications network that connects computer networks and organizational computer facilities around the world (Merriam-Webster, 1999).

IT: Instructional Technology; the theory and practice of design, development, utilization, management and evaluation of processes and resources for learning (Seels & Richey, 1994).

Procedural Skills: an individual's performance on a particular task. In this study, ICT Procedural Skills (performance with computer tools) was measured using the ICT Literacy - Performance Test.

Self-Efficacy: a person's own perception of one's ability to cope with a particular situation or how competent one is to do a certain task. Bandura (1977, 1986, 1989, 1996) has studied this topic on a continuing basis and found that an individual's beliefs about their abilities impact their psychological, cognitive, social, and academic functioning.

SES: Socio-Economic Status; an individual's (or family's) social and financial standing relative to others in society, which is based on factors such as income, education level, occupation, and social status in the community. SES was measured in this study in two ways (1) as financial means (able to purchase a home computer) and (2) education of parents. Data was collected using two questions on the ICT Literacy - Student Background Survey: "Do you have a home computer?" and "What is the highest level of schooling completed by either of your parents?".

Student Demographic Characteristics: background information about the participants. In this study, characteristics deemed relevant to ICT Literacy (such as the titles of software they have used, or the number of years they have used computers) were collected via the ICT Literacy - Student Background Survey.

WWW: World Wide Web, or sometimes referred to simply as "the Web". It is the part of the Internet designed to allow easier navigation through the use of graphical user interfaces and hyperlinks between different Internet addresses (Merriam-Webster, 1999).

Organization of this Thesis

Chapter I has provided an introduction to this thesis, including a statement of the problem investigated and a listing of the research hypotheses tested. Chapter II will provide a review of literature related to the areas investigated in this study. Chapter III will cover the research methods, and Chapter IV the results. This thesis will culminate with Chapter V, which will include a discussion related to the hypotheses, implications of this study, and recommendations for further related research.

CHAPTER II: LITERATURE REVIEW

It is often said that to fully comprehend where you are, you have to understand where you've been. This is perhaps as true in understanding the application of ICT in education as it obviously is to understanding world history. Thus, to understand "where we've been," this chapter begins with a brief review of the history of educational computing, which provides important background information for understanding widespread attitudes towards the use of ICT in schools. This is followed by an overview of historical and current issues regarding the controversy regarding the effectiveness of computers in schools, which again has implications on attitudes towards the use of ICT in schools. Next, this chapter discusses recently adopted ICT standards for students and teachers, which is one indicator of the perceived importance of ICT in schools, and thus support for the importance of this study. The literature review then examines the status of ICT in teacher education programs, since the question of ICT literacy among pre-service teachers is a central issue in this study. Next, the question of availability of tools for assessment of ICT skills is addressed, which provides support for the decision to develop new instruments in this study. Finally, this chapter culminates with a review of research that has examined individual differences in computer expertise, providing a basis for the prediction component of this study.

History of Educational Computing

A brief review of the history of educational computing illustrates the changing role of ICT in schools. This history dates back almost fifty years and broadly speaking, can be viewed as having gone through three phases (Starr, 1996). The first phase (from the mid-1950s to 1980) was characterized by a focus on the development of computer-assisted instruction (CAI) and the teaching of computer programming. The application of computers in education consisted of just a few, large, government/military-funded CAI undertakings such as the IBM 1500 CAI system and the University of Illinois PLATO ("Programmed Logic for Automatic Teaching Operations") project (Alessi & Trollip, 1999). Until 1978, most instructional computing occurred on big "mainframe" computers and existed only at large universities or corporations. However, that year saw the release of the Apple II, the first widely available "personal" computer (Alessi & Trollip, 1999).

The 1980s represented the second phase in educational computing in which the proportion of schools with computers rose to over 90 percent, student-computer ratios dropped dramatically, and schools began to incorporate computing into other activities besides specialized programming courses. These changes were fueled by the spread of personal computers and general application software such as word processing, spreadsheets and databases, as well the expansion of desktop computers into business and industry (Alessi & Trollip, 1999).

1984 was a key point in this second phase and it was nothing like George Orwell's (1949) ominous book. Apple released the Macintosh computer with its Xerox Star System-inspired graphical user interface (GUI), sound capabilities, and mouse-pointing device, along with the "Apple Toolbox," a collection of common software components for application developers. A whole new era in ease of use and accessibility to computer technology had begun. The potential quality of courseware and ease of courseware development were enhanced tremendously by these more ergonomic, intuitive systems. People could use the computer in a more visual way, instead of having to memorize and type often-obscure text commands. Non-technical users were now provided with a simple, consistent interface to the computer (Canavan, 1993). In 1985, Microsoft released a similar GUI-based operating system called Windows for IBM-compatible computers (which would eventually dominate the desktop computer market in the 1990s).

In schools however, computers were still typically located only in special laboratories and student time on computers was limited. Computers were used mainly in special computer literacy or programming classes or in "integrated learning systems" for the purpose of drill-and-practice in basic skills. Computers had not yet dramatically impacted the core curriculum or general educational experience. However, unlike previous technologies (such as motion pictures) which failed to live up to expectations for educational reform, "much of the interest in computers was coming bottom-up from teachers and students, not merely top-down from administrators" (Starr, 1996). New possibilities were emerging as educators realized that computing was more flexible than previous technologies - easily adapted to different content areas, learning styles, teaching styles, and either student-centered or teacher-centered activities.

The third phase in the history of educational computing, dating from the 1990s to the present, has been characterized by a multimedia explosion, the exponential growth of the Internet (especially the WWW), and great advances in ease-of-use and affordability of powerful systems. Much research has focused on making computer systems even more natural and flexible, such as the voice-controlled interfaces or virtual reality environments that are emerging.

This third phase of educational computing has seen significant growth in educational use of the Internet for purposes such as administration, course delivery, publishing, and professional networking. Internet-based communications facilitate a wide variety of collaborative learning activities with the capability of world-wide participation such as: research data collection, social action projects, information exchanges, virtual field trips, keypals, and electronic appearances by experts or special guests. Computers are now found in classrooms as well as labs. This past decade we have begun to see the "transformation of computing from a segregated activity into a ubiquitous part of the everyday work, school, and home environment" (Starr, 1996). The computer is no longer just a "number cruncher;" it is also a flexible tool for human communication.

Effectiveness of Computers in Schools

Answers to the question of the effectiveness of computer technologies in schools have been sought for many years, yet remain somewhat elusive (Hannafin, Rieber, Hannafin, Hooper, & Kini, 1996). Two of the major types of research in this area are: (1) those that focus on the overall effectiveness of computer-based versus non computer-based learning systems (particularly with respect to student test scores), and (2) those that attempt to identify the unique learning contributions of computer-based learning environments.

The effectiveness of computer-based instruction (CBI) has frequently been investigated using the statistical technique of meta-analysis (in which the findings of several related studies are pooled in order to make inferences regarding a collective body of research). Among the most well known of these are the studies published by Kulik and his associates at the University of Michigan (Bangert-Drowns, Kulik, & Kulik, 1985; Kulik & Kulik, 1991; Kulik, 1994; Kulik, Kulik, & Cohen, 1980). A major focus of these studies was to compare student scores on national, standardized, or study-specific tests of achievement for a computer-using group versus a non computer-using control group. These meta-analyses generally reported that computer-based instruction produced small, positive, significant effects on student achievement, a reduction in the time required for learning, and more positive student attitudes. A more recent report on educational technology research (Schacter, 1999) examined meta-analyses and other large scale studies and similarly concluded that students with access to CAI, integrated learning systems, simulations, collaborative networking and other computer-related technologies generally benefit from gains in achievement, more positive attitudes towards learning, and significant reductions in learning time.

However, these types of studies did not go unchallenged. In fact, a furious debate on whether technology affects student outcomes has been burning for the past two decades ever since Clark (1983) first questioned the research on effectiveness of media in education. Clark has been the most vocal critic of this research, with a major claim being that most effectiveness studies suffered from confounding variables such as instructional methods, curriculum content, or novelty (Clark, 1985). In the 1990s he continues to argue that "media will never influence learning" (Clark, 1994).

However, "to many, the focus on whole-effect, meta-analysis research is misdirected" (Hannafin et al., 1996) and often turns attention away from potentially more important questions. Rather than just asking "if" ICT is effective, rather than just replacing old media with computers to make things work faster or more efficiently, we should be investigating how to exploit the unique capabilities of ICT to create new possibilities in teaching and learning. For example, Kozma (1991, 1994) responded to Clark by suggesting that research should not focus on technology as a medium to deliver information, but rather the new possibilities that emerge as the learner collaborates with the medium in the pursuit of knowledge construction.

Two extensive documentary reviews produced by researchers from Laval and McGill universities (Bracewell et al., 1998; Réginald Grégoire inc. et al., 1996) are examples of the type of research into ICT effectiveness that attempts to identify the unique learning contributions of ICT-based learning environments. These reviews took a more qualitative approach than the meta-analyses by examining the literature in search of general trends concerning how use of ICT may potentially benefit learners and teachers. According to these studies, ICT may contribute to various aspects of teaching and learning such as (1) greater motivation, attention span or concentration during learning activities, (2) stimulation to more deeply investigate subjects due to easier access to information, searching capabilities and other ICT functions, (3) cooperation and collaboration among students in the same class or extension of the learning community beyond the school walls via telecommunications, (4) more realistic and authentic learning environments and greater assimilation of concepts due to simulations, virtual experiences, graphic representations, access to data and other ICT capabilities, (5) increased teacher interaction with students and more as a mentor than a supplier of knowledge, (6) more demanding forms of assessment including greater involvement of students in assessment, (7) easier and quicker teacher access to instructional resources, and (8) more just-in-time and collaborative professional development.

However, the Laval/McGill documentary reviews also emphasized that it is not the computer-based technologies on their own that produce changes, but rather it is how technology is incorporated into instruction that matters. Computer technology can be an important aspect in creating new types of learning environments, but, as with any tool, in order to be effective it must be "embedded within practices and activities that realize its functionality for specific purposes and situations" (Réginald Grégoire inc. et al., 1996). Furthermore, these reviews also concluded that a prerequisite condition to effective use of computer-based learning technologies is that both students and teachers have the knowledge and skill to use the technology. It was observed that in those studies that did not expressly consider the computer literacy level of the participants, student achievements were markedly weaker. It was conjectured that the power, ease-of-use or intuitiveness of the technology is often over-estimated.

Many studies have discussed the particular contribution of Internet-based technologies in improving accessibility to learning opportunities and resources. One of the primary advantages of the Internet in post-secondary education is that it can remove the physical boundaries of classrooms, reduce class scheduling restraints, minimize residency requirements, harmonize with family commitments, and offer easy access to searchable databases and a vast array of other world-wide resources (Owston, 1997). The Web is an open technology - it is accessible by any modern computer and is playing an increasingly important role in the area of distance education. Web-based learning can supplement or replace traditional distance educational opportunities provided in the past via postal correspondence, printed materials, audio or videocassettes, and television. According to Bates (1995), "Access is usually the most important criterion for deciding on the appropriateness of a technology for open or distance learning." The Internet's great strength is that it can make instruction time-independent and location-independent; it is able to reach students whenever and wherever they find it convenient to learn (in their homes, at work, etc.).

The Internet may also play an important role in the economical delivery of instruction. Freeman and Ryan (1997) indicated that "specialist courses which can no longer be supported by drawing on the student base in the traditional university catchment area can now be offered economically world wide." Faulhaber (1996) stated that the Internet makes economic sense in the delivery of low-enrollment university courses. Sending the course to multiple campuses lowers the per-pupil cost. Various authors (Hackbarth, 1997; McKenzie, 1997; Owston, 1997) see a similar promising case for the use of the Web in K-12 education. For example, high school students can enroll in externally developed online high school courses, which might be impossible locally due to limited budget, small enrollments, lack of facilities, or lack of qualified teachers.

Still, many people continue to question the value of computers in education and whether ICT expenditures are worth it. Noble (1998) argued that Internet-based technologies are playing a role in the degrading of higher educational institutions into "digital diploma mills." He claimed that university administrations have become enslaved to large corporations in this commercialization of education and the losers are students, professors, and a once-democratic system. Rather than improving learning and widening access, Noble contends that such technologies reduce the quality of education, are forced upon faculty and students, and mainly benefit the commercial interests.

Postman (1995) argued that educators seem to be constantly seeking a master formula to simplify teaching to some sort of automated process, and that many educators have been oversold on technology, viewing it as a "panacea" capable of curing all of education's ills. Allocating substantial resources to educational technology is evading the real social, moral, and spiritual issues that need to be dealt with in education today. Postman claimed that schools could do absolutely nothing in the area of educational computing, and the majority of people would know how to use computers within ten years anyway, due to the emphasis on computers in many other aspects of society. Another author stated:

> There is no good evidence that most uses of computers significantly improve teaching and learning, yet school districts are cutting programs - music, art, physical education - that enrich children's lives to make room for this dubious nostrum, and the Clinton Administration has embraced the goal of "computers in every classroom" with credulous and costly enthusiasm (Oppenheimer, 1997).

At the same time, others stress that the debates on the merits of educational technology have been futile. We have been asking the wrong question:

> Some researchers are questioning expenditures for technology in education: Are learning outcomes significant, do media influence learning, and is it cost-effective? … [They] are asking the wrong question. Our responsibility as educators is to prepare students to be productive citizens. Rote knowledge is no longer sufficient to that end. Technological skills and self-efficacy with computers are as fundamental to education as English, math, or science. Without technology in schools, we will cripple our education system and handicap our students (Dusick, 1998, p. 10).

Early educational computing typically emphasized rote learning in areas such as studying about computers (e.g., naming computer parts), or CAI which provided repetitive practice of basic skills (e.g., math, language arts). Such CAI was often ridiculed as mere "electronic flashcards," or "drill-and-kill" (Starr, 1996). Even experts within the field of educational technology echoed these same sentiments: "The criticism of early lessons as little more than electronic page-turners was, for the most part, well founded" (Hannafin et al., 1996, p. 379). However, current thinking is that the potential of ICT in schools is far more extensive - ICT can be used as a cognitive tool in learning activities that emphasize higher-order mental processes. Using a student-centered, constructivist approach, computer-based tools such as databases, spreadsheets, telecommunications, multimedia authoring, concept mapping, simulations, or computer programming environments are potential "Mindtools" (Jonassen, 1996). The learner can enter an intellectual partnership with the computer, in order to access and interpret information, organize and represent personal knowledge, and solve problems. Authentic, complex projects completed with such tools represent the best use of ICT (Johnson, 1996).

ICT Standards for Students and Teachers

Although controversies continue concerning the use of ICT in schools, many educational organizations and ministries of education have taken the position that ICT should be implemented in schools and have recently developed information technology standards for K-12 students. The International Society for Technology in Education (ISTE, 1998) released *National Educational Technology Standards (NETS)*. These standards are very comprehensive, covering technical skills, problem-solving skills, and awareness of ICT-related social, ethical, and human issues, as indicated by the following excerpt of grade 5 expectations:

> Students will: ... Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide. ... Use general-purpose productivity tools and peripherals to facilitate learning throughout the curriculum. ... Use technology tools (e.g., multimedia authoring, presentation, Web tools, digital cameras, scanners) for publishing activities to create knowledge products for audiences inside and outside the classroom. ... Use telecommunications and online resources to participate in collaborative problem-solving activities. ... Determine which technology is useful to address a variety of tasks and problems. ... Evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources (ISTE, 1998, p. 11).

Most of the American states have (or are in the process of) establishing similar standards (Milken Exchange on Educational Technology, 1999c). The province of

Alberta recently released *Information and Communication Technology, Kindergarten to Grade 12* (Alberta Learning, 2000), which was based on an earlier interim ICT curriculum (Alberta Education, 1998). The Alberta program describes ICT outcomes that are to be embedded across all curriculum areas, rather than as a standalone program of studies. The following is an excerpt from the Division 3 (Grade 7 - 9) outcomes:

> The student will be able to: troubleshoot technical problems ... identify the cultural impact of global communication ... perform routine data maintenance and management of personal files ... design a document that incorporates advanced word processing techniques, including columns, table of contents, bibliography and index ... design, create and modify a database [or] spreadsheet for a specific purpose ... create multimedia presentations that incorporate meaningful graphics, audio, video and text ... create a multiple-link web page ... demonstrate proficiency in accessing local area network, wide area network and Internet services ... evaluate the authority and reliability of electronic sources (Alberta Education, 1998, pp. 11 - 25).

Standards for students imply standards for teachers, but specific standards for teachers have also been published. *National Standards for Technology in Teacher Preparation* (ISTE, 1997) provided recommendations to the U. S. National Council for Accreditation of Teacher Education including the following excerpts from the "Recommended Foundations in Technology for All Teachers":

> Candidates will … evaluate performance of computer systems … apply basic troubleshooting strategies … use terminology related to computers and technology … use imaging devices such as scanners, digital cameras … use productivity tools for word processing, database management, spreadsheet applications, multimedia presentations … use telecommunications to access information and enhance personal and professional productivity… demonstrate awareness of resources for adaptive assistive devices for student with special needs … demonstrate knowledge of equity, ethics, legal, and human issues concerning use of computers and technology … design, deliver, and assess student learning activities that integrate computers/technology.

Such standards serve important purposes. They "draw public attention to problems and opportunities in education, ... constitute the foundation on which policymakers base funding initiatives, ... [and] provide crude benchmarks for judging educational progress" (McNergney, 2000, p.1). However, McNergney cautioned against expecting too much from standards; there is a limit to the extent to which standards will drive educational reform concerning the use of technology in teaching and learning. Beyond just setting standards, it is important that teacher educators be supported to model creative use of technology and that new measures of teacher performance (including technology-related criteria) be built.

ICT in Teacher Education Programs

A report on school technology readiness (CEO Forum on Education and Technology, 1999) stated that teachers hold the key to helping students thrive in today's world and tomorrow's workplace. The transformation of classroom technology into tools for teaching and learning depends on knowledgeable and enthusiastic teachers who are motivated and prepared to put technology to work on behalf of their students.

However, an American survey on information technology (Milken Exchange on Educational Technology & International Society for Technology in Education, 1999, p. i) reported "in general, teacher-training programs do not provide teachers with the kinds of experiences necessary to prepare them to use technology effectively in their classrooms." Of the teacher training programs surveyed, over 70 percent required students to take at least three credits of ICT instruction. However, most faculty felt that ICT training was inadequate and that they do not model effective technology use in their classrooms. It was also found that most student teachers do not routinely use ICT during field experiences.

> The use of technology in everyday classroom and practicum experiences seems to be more important than specific computer classes … specific technology training has a role, but only up to a point. The institutions that reported the highest levels of student technology skills and experience were not those with heavy computer course requirements, but those that made use of technology on a routine basis throughout the teacher training program (Milken Exchange on Educational Technology, 1999a).

Cherup and Linklater (2000) concurred with the above in describing a promising model for integrating technology into preservice education. Technology is integrated into existing curriculum, rather than taught in separate courses. "Modeled by professors, its prominence diminishes and course content remains the essence ... technology, teaching, and learning become seamless" (Cherup & Linklater, 2000, p. 18). First the pre-service teachers recognize the value of technology in their professors' teaching and then they are required to complete projects that use similar tools. However, these authors added that the effort involved in teaching computer technical skills cannot be ignored because the professors are often novice users of computer applications themselves and already struggling with a full curriculum. As another author stated:

> Computer literacy is still, however, a major problem for preservice and inservice teachers. ... The gap between the ones that have and the ones that have not the basic skills is highly perceptible in the teaching profession, whether at the entry level or later in one's career. Yet, much progress has been accomplished over the last four years, and the group of early adopters has reached a critical mass, as demonstrated by the number of preservice students having an e-mail address, and access to a networked personal computer (Bracewell et al., 1998).

Improving the coverage of ICT in teacher education programs is a complex challenge. There are many factors that impact technology in pre-service teacher programs including faculty professional development, faculty incentives, funding, technology infrastructure, technical support, leadership, long-range planning, accreditation standards, technology use in K-12 schools, and technical competency of incoming students (Bielefeldt, 2001).

> Infusing technology into teacher preparation requires a comprehensive approach that attempts to balance facilities, faculty professional development, coursework, and field experience (Bielefeldt, 2001, p.10).

Assessment of ICT Skills

DeWert (2000) argued that it is essential that schools of education set high standards concerning ICT literacy and candidates' ability to use technology to help students learn. She has developed the "Essential Conditions Quiz," a guide for evaluating the status of teacher preparation programs relative to technology. DeWert viewed technology-related assessments as an important part of exemplary teacher education programs as indicated in the following excerpt from the quiz:

> Does your program have an assessment system that collects data on the performance of candidates and graduates relative to its educational technology standards? Does your program use these performance data to advise individual candidates and to improve the program's technology-

> related efforts? Does your program administer multiple technology-related assessments in multiple forms at multiple decision points (e.g., at entry to program, prior to clinical practice, at program completion, after the first year of teaching)? (DeWert, 2000, p.4).

Technical skills themselves are the not the only focus of the assessments DeWert advocates; it is ultimately the ability to incorporate technology into teaching that is important. However, both technical skills and knowledge should be considered to some extent in the assessment process. An assessment tool such as the prototype being developed in this study could provide useful data at program entry or other points in an education undergraduate program.

Currently, there is no assessment tool or information available which indicates the ICT skill level of students entering post-secondary studies at this university. Alberta Learning (1999c) proposed classroom-based tools that teachers will use to assess achievement of the technology outcomes. However, there are no plans to provide any specific data that would be available to post-secondary institutions to establish entrance qualifications in this area. Neither is there any information provided in conjunction with the U.S. NETS (ISTE, 1998) concerning the evaluation of student achievement of those standards.

A few business-oriented software products, such as SAM 2000 (Course Technology, 1999) or Skill Builder (National Education Training Group, 1999) are available for assessing individual expertise with particular application programs. These products offer an authentic type of assessment, as the students must demonstrate skill acquisition in a live application environment or in a very realistic simulated environment. However, these types of systems are not suitable for use in this study for several reasons: (1) they are not available on the Macintosh (Apple Computer Inc., 2000) platform (due to the facilities in this faculty, this study must be prepared to test students on both the Windows (Microsoft Corporation, 2000d) or Macintosh platforms), (2) specific software must be purchased for each different application program being tested and is limited to one particular version of the software such as Microsoft Word 2000 or Excel 2000 (Microsoft Corporation, 2000c), which could be a very expensive, complex solution, and (3) these products are generally intended to prepare individuals for "Microsoft Office

User Specialist" certification. It is mainly the skills expected of a highly proficient user that are tested (e.g. an individual who is expected to work with a particular application program in a non-educational environment for a significant portion of their working hours); there is very little content in these products that addresses entry-level skills.

In addition, various tools for self-assessment of ICT skills are available to pre-service or in-service teachers. Examples are the California Technology Assessment Profile (California Department of Education, 2001), the Professional Competency Continuum (PCC) developed by the Milken Exchange on Educational Technology (1999b), the Technology Competencies Database developed at the University of Illinois at Urbana-Champaign (Waugh, Levin, & Buell, 1999), and the Technology Proficiency Self-Assessment (TPSA) scale (Ropp, 1999) developed at the University of New Mexico (which was in turn based on the Michigan State University Education Technology Proficiency checklist). These tools were all based on student self-reports and use general checklists. However, upon consulting many research sources including educational technology journals, the ERIC database, Academic Search FullTEXT Elite (EBSCOhost) and the Dissertation Abstracts Database, no information was located concerning the type of assessment tool desired for this research. This study requires detailed data from an objective, consistent test, in addition to student self-reports (this study collected some self-reported data concerning previous computer experience). For example, this study assessed what a student understands about using spreadsheets, by asking direct questions that require experience with various aspects of using such a tool or require students to perform particular operations using an actual spreadsheet program. It did not simply ask "Have you used a spreadsheet?" or "How well do you know how to use a spreadsheet?", which is what most self-reports would ask. Students may not be aware of how much they do not know about software tools. The lack of suitable tools for evaluating student ICT skills in this way justified development of a new instrument.

Characteristics Associated with ICT Expertise

There is a wide array of variables that could offer plausible explanations for differences in ICT expertise in undergraduate students. This section begins with a discussion of academic ability, as research has frequently shown that current academic achievement is usually very highly correlated with previous academic achievement (Fraenkel & Wallen, 1996). Other major issues found in the literature specifically with regard to learning to use computers include gender, attitudes, self-efficacy, and previous computer experience (Houle, 1996; Ropp, 1999). A U. S. government report (President's Committee of Advisors on Science and Technology, 1997) discussed additional concerns related to socio-economic status (SES).

Academic Ability

One obvious predictor that should be examined is general academic ability. Research has repeatedly shown that post-secondary achievement is highly related to prior academic achievement, such as high school grades, college entrance examinations (e.g., SAT - Scholastic Aptitude Test or ACT - American College Testing), or previous college grades (Beecher & Fischer, 1999; Borde, 1998; Fraenkel & Wallen, 1996; Mulvenon, Stegman, Thorn, & Thomas, 1999; Peters, 2000; Roth, Crans, Carter, Ariet, & Resnick, 1999; Wright & Palmer, 1998). The cited studies indicated that general academic ability (as measured by previous academic performance) is often the strongest predictor of academic success in college students. A statewide study of grade 8 students (North Carolina State, 1998) revealed that 98.7 percent of academically gifted students passed a test of computer skills (including multiple-choice and performance components) while only 74.8 percent of all students who took the tests met the requirement. This suggests a possible correlation between general academic ability and computer-related abilities. A review of many research sources including educational technology journals, the ERIC database, Academic Search FullTEXT Elite (EBSCOhost) and the Dissertation Abstracts Database, found no studies that tested whether the computer literacy level of college students is related to general academic ability.

Gender

Gender has long been identified as an equity factor in mathematics, science, and technology. Although great increases in gender equality have occurred in Western society over the past few decades, there is still a lack of interest in technology among females, technology-related jobs continue to be male-dominated, and only 25% of computer science degree recipients are women (Dumett, 1998). In a review that covers hundreds of studies on the impact of educational technology, Schacter (1999, p. 6) stated, "the relative disadvantage of girls is a regularity of the technology literature." Other studies indicate that there is gender bias and stereotyping in educational software (Pisapia, 1994), females are "less likely to acquire technological competence" (Bryson & de Castell, 1998) and fewer women than men own a computer or have Internet access (Crow & Longford, 2000). Crow (2000) also claimed that females do not easily relate to computer terminology because of its military origins, for example words such as "launch" or "abort."

However, other studies question the traditional view that males do better at computer activities and have more access to technology than females. Johnson and Szabo (1998) found that female high school students were more successful at using Internet search tools than their male counterparts. A study of grade eight students found that 79.1% of females (compared to 70.6% of males) passed a computer proficiency test (North Carolina State, 1998). The instrument used in the North Carolina study included both declarative and procedural components, which each accounted for half of the overall score. However, the report did not provide a breakdown of the achievement on each of the two components by gender, only overall scores were reported. A United States government study (U.S. Department of Commerce, 2000) indicated that, as of August 2000, Internet usage between men and women was virtually equal (44.6% of men and 44.2% of women were Internet users). A recent study (Miller, Schweingruber, & Brandenburg, 2001) suggested that largely due to the rapid acculturation of youth to the World Wide Web, gender gaps that once existed in ICT access, and perceived confidence levels regarding computer use, have significantly narrowed. Thus, the literature on gender and technological skills is rather conflicting.

Computer Attitudes and Self-Efficacy

Negative attitudes toward ICT and low computer self-efficacy have been the focus of a number of studies and have been shown to be associated with low levels of computer proficiency and adoption (Ropp, 1999). Weil and Rosen (1997) conducted numerous investigations on the psychological impact of technology and how attitudes are often associated with resistance to technology adoption. For example, one of their studies (Rosen & Weil, 1995) found that "technophobia" explained low levels of computer use among elementary and secondary teachers and that prominent predictors of fears regarding computer use included amount of computer experience, age, gender, and school SES.

There is also some evidence that elementary education students appear less interested in ICT than those aiming to teach older students. A recent study on elementary teacher beliefs concerning the use of technology in education (Ertmer, Addison, Lane, Ross, & Woods, 1999) indicated that many such teachers feel that it is not necessary to have computers in the earlier grades - computers are seen as an optional add-on. However, the U.S. NETS and Alberta standards, both based on extensive reviews and input from a wide range of stakeholders, clearly indicate support for the integration of ICT starting at the earliest grade levels, that it "is as important in grade 1 as it is in grade 12" (Alberta Education, 1999b, p. 2). Exploring whether choice of program route is associated with ICT skill level may help clarify whether special interventions for development of ICT skills in elementary education students are advisable. It also seems plausible that this factor may be influenced by gender, given the high proportion of females in elementary education.

Rosen and Weil (1995) also found that elementary and secondary humanities teachers were particularly "technophobic." The teachers' major worries concerned learning to use computers, operating computer hardware in the school, and an inability to deal with computer errors. There is likely a general belief that individuals more connected with science, mathematics and technologies relate more naturally to computers and find them easier to learn to use. This belief is understandable given the computer's early history as a machine used mainly as a "number cruncher" by scientists and the military. It would thus be interesting to investigate whether university students focused on humanities have generally lower ICT literacy than students focused on science, mathematics or technologies.

Previous Computing Experience

As mentioned in the previous section, Weil and Rosen (1997) identified amount of computer experience as an important issue that impacts an individual's level of comfort with technology. Courses that provide hands-on training usually result in significant improvements in technology proficiency and computer self-efficacy in pre-service teachers (Ropp, 1999). Another study found that student differences in an undergraduate computer skills course could be explained by prior computer experience such as high school computer courses, as well as other factors, including gender, college major, computer self-efficacy, attitudes, and anxiety.

Other research studies also suggest that it takes time to understand and use technology well and that individuals go through a continuum of stages of technological use (Overbaugh, 1993). One theory (Mandinach & Cline, 1992) labeled these stages survival, mastery, impact, and innovation while another framework (CEO Forum on Education and Technology, 1999) proposed five stages: entry, adoption, adaptation, appropriation, and invention. Basically what these types of theories suggest is that a person moves from complete unfamiliarity to trying/struggling, to increased technical competence/coping, to feeling less threatened/viewing technology as a partner, and finally to discovering new uses and leveraging the power of technology. Thus, students with very limited previous computer experience would likely find college courses that require the use of computers rather challenging, compared to students who are at more advanced stages of technological use.

Socio-Economic Status

SES refers to an individual's (or family's) social and financial standing relative to others in society, which is based on factors such as income, education level, occupation, and social status in the community. SES is an issue worth investigating in this study because it correlates in general with academic achievement (Wendel, 2000). It is one of the principal macro-level or structural factors (as opposed to individual characteristics) that explain differences in student performance on standardized tests (Baker, McGee, Mitchell, & Stiff, 2000). Poverty and related factors divert children's attention from education and increase the likelihood of not completing high school, not graduating from college or being unemployed (Levine & Nidiffer, 1996).

SES is also related to access to technological resources and experiences (Foxhall, 2000; Pisapia, 1994; Tapscott, 1997). Public funding for technology resources in schools may lessen the gap between poor and rich areas (President's Committee of Advisors on Science and Technology, 1997) and the policy of education ministries such as Alberta is to provide equitable funding for all schools. However, SES-related inequalities in educational technology opportunities are still prevalent (Leigh, 1999; National Science Board, 1998).

Furthermore, the most critical disparities in access to technology are in students' homes. For example, in 1995, only 14% of households headed by adults with a high-school education or less and annual income less than $30,000 had a computer, whereas 73% of college-educated/$50,000 or more households had a computer (President's Committee of Advisors on Science and Technology, 1997). A series of reports (U.S. Department of Commerce, 1995-2000) revealed that computer and Internet use have been generally increasing over the past few years in American households across all demographic groups (income, education, ethnicity, geographic location, household type, age or gender). A "digital divide" still exists between "have" and "have-not" groups, but some of the gaps are beginning to narrow. For example, those with higher income and education still are more likely to have home Internet access, but between 1998 and 2000, households in the lower income bands registered increases in Internet access much faster than the national gain.

Summary

The role of ICT in schools and the perception of its importance have changed since its inception in the mid 1950s. Educational computing, at first an activity restricted to an elite few, or occurring in segregated facilities, is now more likely to occur in regular classrooms and include virtually any student or teacher. The computer, once a large, number crunching, unconnected, difficult-to-manage machine, is now smaller, more portable, easier to use, and can allow the user to communicate with others and use resources worldwide.

Early research on the effectiveness of computer-based instruction did not provide unanimous results. Some studies indicated that use of computers resulted in small positive gains in test scores, reduced learning time, higher motivation, and greatly increased access to instruction, whereas other studies argued that most of this "media comparison" research was confounded due to uncontrolled variables. Newer research is moving away from media comparison and the focus on test scores to a more extensive exploration into the emerging contributions of new technologies such as increasing access to learning opportunities and resources and facilitating learning that is more authentic, student-centered, cooperative or collaborative.

There are few, if any, assessment tools or research results that fit the purposes of this study, although numerous professional bodies have specified standards for teachers and students. The literature also indicates that most teacher education programs do not effectively prepare teachers to integrate ICT. Schools of education should set technology standards that are congruent with government standards, should assess the performance of teacher candidates relative to these standards, and should model the use of technology to prospective teachers.

Finally, general academic ability, gender, attitudes and self-efficacy concerning computers, amount of previous computer experience (in or out of school) and SES (particularly as related to home computer ownership) are some of the major factors that the literature indicates may be correlated with ICT proficiency in individuals, or in particular, post-secondary students.

CHAPTER III: RESEARCH METHODS

Introduction

This chapter describes the hypotheses, variables, participants, ethical considerations, research design, procedures, instrumentation, data collection methods, and data analysis techniques pertaining to this study. In the first part of this study, computer-based tools for gathering demographics and assessing ICT knowledge and skills were developed and pilot-tested. The second part of the study involved testing a large number of undergraduate education students to obtain a baseline assessment of the ICT literacy level of the group of students as a whole and to determine which participant characteristics were associated with higher ICT literacy. The students were tested a second time after taking an educational technology course to determine what additional impact the course had on their ICT literacy.

The assessment system provided evaluation of ICT expertise from two theoretical perspectives: (1) a test of declarative knowledge (familiarity with ICT terminology and concepts), which was the more traditional, quicker, and easier to score type of assessment; and (2) a performance test, in which the students applied their ICT knowledge as they worked through various practical computer tasks. Authentic learning and assessment are dominant themes in current educational theories and have been increasing in application since the 1980s (Shuell, 1996). This study also provided data that indicated the extent to which student achievement on these two types of tests was correlated.

Research Hypotheses

In this study, hypotheses were examined regarding assessing ICT literacy, predicting ICT literacy, and trends in ICT use in schools.

Assessing ICT Literacy

1. The mean pre-test scores on both ICT Knowledge and ICT Performance will be significantly lower than 80% (an assumed mastery level).

2. The mean post-test scores on both ICT Knowledge and ICT Performance will be significantly higher than the corresponding pre-test scores.

Predicting ICT Literacy

3. The dependent variable ICT Literacy Composite Pre-Test (and Knowledge and Performance sub-scores) can be significantly predicted by some linear combination of one or more of the independent variables examined in this study.
4. The direction of the contribution of the following categorical variable values in the prediction of ICT Literacy Pre-Test (and Knowledge and Performance sub-scores) will be positive:
    a. Gender = Male (var. 1a)
    b. Home computer = Yes (var. 2a)
    c. Other Access to Computer (workplace/other household) = Yes (var. 2c)
    d. Urban/Rural High School = Urban (var. 3d)
    e. Post-Secondary Experience = After-Degree/Fifth year or more (var. 5a)
    f. Program Route not = Elementary Education (var. 5b)
    g. Program Focus = Science/Math/Technology related (var. 5c)
    h. Previous Post-Secondary Credit Computer Course = Yes (var. 5d)
    i. Previous Non-Credit Computer Course/Workshop = Yes (var. 5e)
5. The direction of the contribution of the following quantitative variables in the prediction of ICT Literacy Pre-Test (and Knowledge and Performance sub-scores) will be positive (higher values of the independent variables will be associated with higher values in the dependent variable):
    a. SES – Parents' Highest Education (var. 2b)
    b. Years of Computer Use in K-12 School (var. 3a)
    c. Number of High School Subjects using ICT (var. 3b)
    d. Year of High School Graduation (var. 3c)
    e. General Academic Ability (var. 4a)
    f. Years of Computer Use (var. 6a)
    g. Variety of Computer Experience - number of software applications used (var. 6b)

  h. Computer Self-Efficacy (var. 7a)
  i. Attitude Toward Computers in Society/Education (var. 7b)

Trends in ICT Use in Schools

6. Recent high school graduates started ICT use in school in earlier grades than those who graduated longer ago.
7. Recent high school graduates had ICT integrated into more high school courses than those who graduated longer ago.

Variables

Independent Variables

Table 1 lists the independent variables used in this study. The variables are grouped under 7 major headings corresponding to the sets used for entering variables into the multiple regression analysis: (1) Individual Characteristics (2) SES (Family/Community Influences), (3) K-12 Education, (4) Academic Ability, (5) Post-Secondary Education, (6) Overall Computer Exposure, and (7) Computer Attitudes. This hierarchy of variables was an adaptation of a multi-level regression model used by Ma (1997) in a study that examined differences in student achievement in high school mathematics. Ma's model was based on the literature concerning the impact of both individual and sociological variables on student learning and achievement. Individual differences can be thought of as emanating first of all from individual characteristics of students (e.g., gender and age), and then further affected by a series of successively more distant societal influences (e.g., family and school), all of which collectively may impact related experiences, attitudes and finally achievement. The present study also incorporated chronological considerations in ordering the variables.

Table 1. Independent (Predictor) Variables

Set	Variable	Source	Type	Values
1. Individual Charact.	a) Gender	BG 19	Categorical	0) Female 1) Male
2. Family/ Community (SES)	a) Home Computer (Financial Means)	BG 1	Categorical	0) No 1) Yes
	b) Parents' Highest Education	BG 15	Ordinal	Integer 1– 9 (<Gr 7 … Doctoral)
	c) Other Access to Computer (work/other household)	BG 6	Categorical	0) No 1) Yes
3. K-12 Education	a) Years of Computer Use in K-12 School	BG 11	Ratio	0) Never 1) Since Gr. 12 … 13) Since K
	b) Number of High School Subjects using ICT	BG 12	Ratio	Integer 0 - 19
	c) Year of High School Grad.	BG 13	Interval	Integer 1900 - 2000
	d) Urban/Rural High School	BG 14	Categorical	0) Rural 1) Urban
4. Academic Ability	a) General Academic Ability	Univ. Rec.	Ordinal	Number 5.0 – 9.0
5. Post-Secondary Education	a) Post-Secondary Experience	BG 20/22	Categorical	0) 4th year or less 1) After-Degree/5th year+)
	b) Program Route	BG 23	Categorical	Educ-Elementary (00) Educ-Not Elem (10) Not Education (01)
	c) Program Focus (Faculty/ Degree/Major/Minor)	BG 21/22/ 24/25	Categorical	0) Not Science/Tech 1) Science/Tech
	d) Previous Post-Secondary Credit Computer Course	BG 16	Categorical	0) No 1) Yes
	e) Previous Non-Credit Comp Course/Workshop	BG 17	Categorical	0) No 1) Yes
6. Overall Computer Experience	a) Years of Computer Use	BG 7	Ratio	Integer 0 - 50
	b) Variety of Computer Experience (number of software applications used)	BG 8	Ratio	Integer 0 - 23
7. Computer Attitudes	a) Self-Efficacy	ATT 1-10	Ordinal	Integer 10 - 50
	b) Attitude Toward Computers in Society/Education	ATT 11-20	Ordinal	Integer 10 - 50

In this study the first variable set is labeled "Individual Characteristics" and contains one variable "Gender." This was determined to be the only completely individual characteristic in the study. Two other variables, General Academic Ability and Year of Graduation (also an estimate of student age) could be considered in one sense to be individual characteristics. However, on the assumption that academic ability, in addition to being a "natural" characteristic, is also affected by "nurture" (e.g., sociological factors such as family SES), General Academic Ability was reserved for a later position in the model. The same is true of Year of Graduation – in addition to indicating a student's age (and by implication, level of development and maturity), it is also an indicator of school conditions that may change over time (and rather dramatically in recent years with respect to technology use, as the results of this study show).

In the study by Ma (1997), the second set of variables was related to family/SES influences, specifically parental education levels. Similarly, in this study, the second set is labeled "Family/Community (SES)" and includes the variables "Home Computer" (a measure of family financial means), "Parents' Highest Education" and "Other Access to Computer at workplace or other household."

The third set in Ma's model introduced school-related variables, as does this study. The set "K-12 Education," includes four variables which may have directly or indirectly affected a student's opportunity to increase their computer literacy: a) Years of Computer Use in K-12 School, b) Number of High School Subjects using ICT, c) Year of High School Graduation (more use of technology in schools in recent years), and d) Urban/Rural High School (possible greater access to technological resources in urban areas).

The fourth set in the model for this study contains the variable "General Academic Ability," which can be thought of theoretically as being influenced by the preceding sets of variables (individual, family/SES, and K-12 school characteristics) and chronologically as preceding the next set of school variables, namely "Post-Secondary Education." A certain level of General Academic Ability is normally required in order to enter post-secondary studies, and this is true for the students in this study. Generally, in order to be admitted to this university, students must have completed at least five grade 12 matriculation level subjects with a competitive overall average. The actual measure of General Academic Ability that was available for use in this study was the GPA presented upon admission to the Faculty of Education at this university, which was based on a pre-professional year of university studies.

The fifth set contains the following variables related to the post-secondary program of studies: a) Post-Secondary Experience (possible greater personal maturity or being "wise to the system" for after-degree (AD)/fifth year or more students, informal data from personal teaching experiences indicate that AD students often get higher course marks), b) Program Route (possible less technology emphasis for elementary education students), c) Program Focus (possible greater technology emphasis in programs where major/minor is mathematics, science, computing, or other technology studies as opposed to humanities), d) Previous Post-Secondary Credit Computer Course (possible source of ICT knowledge/skills), and e) Previous Non-Credit Comp Course/Workshop (possible additional, more informal, source of post-secondary computer training).

The sixth set of variables identified in this study are two general measures of "Overall Computer Exposure" which likely have been influenced by all of the previous sets of variables: a) Years of Computer Use (the elapsed time since individual's first exposure to computers), and b) Variety of Computer Experience (number of software applications used). It can be argued that if a person's computer-related experiences due to the previous variables have been broader, they may have been using computers for a longer time, they may have been exposed to a larger number of application software programs, and, consequently, ICT Literacy might be positively impacted.

The seventh and final set of independent variables used in this study are in the area of "Computer Attitudes": a) Self-Efficacy (personal feelings of being capable and unafraid of using computers), and b) Attitude Toward Computers in Society/Education - personal opinions about the importance and usefulness of ICT in society in general, and in particular, in the education system (see Instrumentation for further details on these measures). This Attitude set represents the most chronologically recent variables and those that may have been influenced by all prior variables in the model. All seven sets of independent variables are then presumed to be exerting an influence on the dependent variable, ICT Literacy and its sub-scores (Knowledge and Performance).

The remaining information in Table 1 provides further details about the independent variables. "Source" indicates the questions on the Student Background Survey (BG) or Attitude Survey (ATT) from which the associated data were obtained (except for General Academic Ability, which was extracted from university student records). "Type" indicates which of the four types of measurement scales is used for each variable: (1) Categorical – simple grouping or labeling of data (also called "nominal," e.g., Gender), (2) Ordinal – indicates relative standing or ranking among individuals (e.g., Parents' Highest Education), (3) Interval – Same as ordinal, plus distances between points on the scale are equal (e.g., Year of High School Graduation), and (4) Ratio – Same as interval, plus scale has a true zero point (e.g., Years of Computer Use). "Values" lists the values possible for each variable. For categorical variables, this indicates the groupings and binary dummy values used in the regression analysis, while for quantitative variables (ordinal, interval or ratio), this indicates the range of possible numerical values.

Dependent Variables

There are six dependent variables used in this study, as shown in Table 2.

Table 2. Dependent Variables

	Variable	Type	Values
Pre-Test	1. ICT Literacy Composite Pre-Test	Ratio	z-scores (~ -3.00 to +3.00)
	2. ICT Knowledge Pre-Test	Ratio	0.00 – 100.00
	3. ICT Performance Pre-Test	Ratio	0.00 – 100.00
Post-Test	4. ICT Literacy Composite Post-Test	Ratio	z-scores (~ -3.00 to +3.00)
	5. ICT Knowledge Post-Test	Ratio	0.00 – 100.00
	6. ICT Performance Post-Test	Ratio	0.00 – 100.00

ICT Literacy Composite Pre-Test was calculated as the mean of the standardized (z-score) versions of ICT Knowledge Pre-Test and ICT Performance Pre-Test. These three pre-test variables were the dependent variables of interest in the regression analysis that identified a model for predicting pre-course ICT Literacy. Similarly, ICT Literacy Composite Post-Test was calculated as the mean of the standardized (z-score) versions of ICT Knowledge Post-Test and ICT Performance Post-Test. These three post-test dependent variables, along with the pre-test dependent variables were of interest in the analyses that compared pre and post-course ICT literacy.

ICT Knowledge and ICT Performance measure two different aspects of ICT expertise. ICT Knowledge refers to declarative knowledge concerning ICT terminology and general concepts as measured by a multiple-choice test. Scores from this test were broken into 7 sections corresponding to the two remedial and five regular modules included in the curriculum of the recommended educational computing course: (1) Computer Basics, (2) Word Processing, (3) Internet Tools, (4) Digital Media, (5) Computer-Based Presentations, (6) Spreadsheets, and (7) Databases. ICT Performance refers to an authentic assessment of ICT procedural skills as measured by a set of hands-on computer tasks. Scores from this test were broken into three sections (1) basic directory and file management (2) basic use of a word processor along with general familiarity with operating system and program commands, (3) the use of basic features of a spreadsheet application program. (See Instrumentation and Data Collection for further details on the ICT Knowledge and Performance Tests.)

Controlled Variables

So as not to confound the results, additional variables were controlled:

1. Invalid Participants: Since this study implemented web-based instruments that were theoretically accessible from any location on the Internet, it was important to minimize the possibility of invalid participants. To this end, the following strategies were employed:
    a) The website was available online during strict data collection time periods only. i.e., only during first week of lab classes at the start of each term.
    b) The students were required to provide their university computer ID on the webpage login form and their first and last name on the consent form. These values were compared against a database of students registered in the courses from which participants were drawn to ensure that nobody who was not registered in those courses would be included in this study.
    c) Only students in the classes of interest received from the researcher a special pass code (which they had to enter when logging into the test webpage). This pass code was supplied in person at the time of administering the tests in the campus labs (or

was communicated personally to distance education students). To the best of the researcher's knowledge, no invalid participants attempted to access the website for this study.

2. Physical Environment: The same campus lab facility was used for testing during both the Fall 2000 and Winter 2001 terms. The lab was renovated in Summer 2000 and was equipped with recent model Macintosh G4 computers and a fast Ethernet network. In this lab environment all individual computers receive regular maintenance so that they are as similar and reliable as possible. Approximately 50 students who were taking their course at a distance were sent an invitation to submit the test from their home computer even though this would alter the physical environment of the test, as it would have been unethical to exclude those students from the study. Only three such students actually participated. The invitation was communicated by posting an announcement on the course website and also by sending a personal email message. However, course staff informed the researcher that many of the distance students did not appear prepared to get started with the course during the first week of the term.
3. Computer Platform (BG10): categorical - 5 levels, (a) No OS Used (b) Macintosh Only (c) Windows Only (d) Macintosh and Windows (e) Other OS
   Windows and Macintosh are the two major platforms or computer operating systems provided for general student use on campus. They both employ a graphical user interface (GUI) and are fairly similar in their operation. The knowledge test contained only generic questions that were not specific to any operating system, and thus was platform-independent. However, the nature of the practical test dictated that it be platform-dependent to some degree. The method for completing most of the practical tasks was similar on both systems, but there were minor differences for a few test items. To alleviate platform familiarity problems during the Fall/Winter testing period, on-campus students were given an introduction to the Macintosh computers prior to the pre-test. The lab instructor explained and visually demonstrated the major differences between the typical Windows-based computer and the Macintosh computers. A simulated Windows interface called Virtual PC (Connectix

Corporation, 2001) was installed on all of the computers, but was not fully operational in time for the Fall term pre-test. It was available for the Winter term pre-test, but only 5 students chose to use it. As noted in the Data Analysis section further in this document, statistics were computed to verify that lack of familiarity with the Macintosh platform did not impact the results of this study.

Participants

The population of interest in this study was undergraduate education students (sometimes referred to as "pre-service teachers"). The sample consisted of students at a major Canadian research university who were registered in two similar educational technology courses (see Appendix A for outlines of the two courses). These courses were offered through the Faculty of Education, and both were accepted to satisfy the computing requirement for Bachelor of Education students. This sample was chosen in order to simplify access to participants and increase the probability of a high response rate, as discussed previously in the Limitations section of Chapter I. Justification for this decision was based on the following facts and assumptions:

(1) All undergraduate education students must include a one-term computing-related option in their program.

(2) One of the two courses is the faculty recommended computing option and the other is an equivalent course. Both are accepted without question as valid computing options. Aside from these two courses, students could fulfill the computing requirement with a non education-oriented computing science class (which focuses on learning a computer programming language) or some other course for which they would have to receive special approval. Informal comments by previous students indicated that the computing science course was viewed as being less useful to prospective teachers and would be a more difficult course than the recommended course.

(3) At the time of this writing, the recommended computing option course serves about 1000 students per year, or 3000 over a three-year period. 85 – 90% of the course enrollment occurs during the Fall/Winter terms, which was the time period for this study. Also, according to the results of this study, 91% of the students registered in

the course actually intend to pursue an education degree (students can take this course before being formally registered in the Faculty of Education). There are about 3000 undergraduate students registered per year in the Faculty of Education, most for a period of three years. The Faculty was not able to provide accurate data on the percentage of education students who present the recommended course as their computing option upon graduation, but these numbers alone imply that it must be very high.

(4) If we tested the students at the start of these two courses, it was likely that we were contacting the majority of them before they had had any substantial amount of post-secondary computing-related instruction. This assumption was supported by the results of this study: 74% of participants indicated that they had not yet taken any other computer-related credit course during their post-secondary studies.

(5) A point of concern with this sampling method (related to the discussion in point 3 above) is that a small portion (6.7%) of students in the target courses stated that they were not pursuing an education degree and thus could not be considered "pre-service" teachers. These students were registered in other faculties and were simply taking this course as an option. However, ethically, these students could not be excluded from the study. All students in the target courses were allowed the opportunity to participate in this study, using the pre and post-course tests to their benefit. Furthermore, including these students in the study allowed a comparison between students pursuing education and students not pursuing education.

During the Fall 2000 term, there were approximately 475 students registered in the first course at the start of the term, of which 385 participated, and 20 registrants in the second course, of which 15 participated. During the Winter 2001 term, there were approximately 400 students registered in the first course at the start of the term, of which 313 participated. Included in the 313 are a small number of distance education students (3) who took the tests in an off-campus location. Due to a personal situation, the researcher was unable to schedule testing for the Winter 2001 term for the second course. The total number of volunteer participants for the pre-test was 713 students out of 895 invited students, a response rate of about 80%.

Ethical Considerations

Participation in this study was voluntary and students were assured of anonymity, privacy, and that the results would not affect their course work or grades. Participants were asked to complete an online consent form (Appendix B) prior to entering the study. On the consent form students had to specifically indicate whether they gave the researcher additional permission to access their university records (previous course grades). A research proposal and sample consent form had been submitted for review to a research ethics board within the university and were approved prior to data collection. In addition, a "proposal to access personal information for research or statistical purposes" (Appendix C) was submitted to the university in order to request access to student grades in the university's record system. The proposal was required to provide information on the following topics: (1) a general description of research project, (2) the rationale for access to personal information, (3) how the personal information would be used, (4) the period of time of use of records, (5) the benefits of the research, (6) data security and confidentiality, (7) telecommunications security, and (8) a description of the records requested. The proposal was approved, which meant that this study met all university regulations concerning access to student records and furthermore complied with the provincial act concerning freedom of information and protection of privacy (Government of Alberta, 2000).

The researcher has extensive experience in designing and teaching the course from which the majority of participants were drawn. During the data collection period, the researcher was responsible for continued development of online materials and computer-based examinations for the course, but did not have any direct involvement in teaching the course or interaction with students. Interaction with the teaching staff of the course was limited to general issues related to administering the research instruments and development of online materials and exams for the course. Course teaching staff did not have access to individual student results on the research tests.

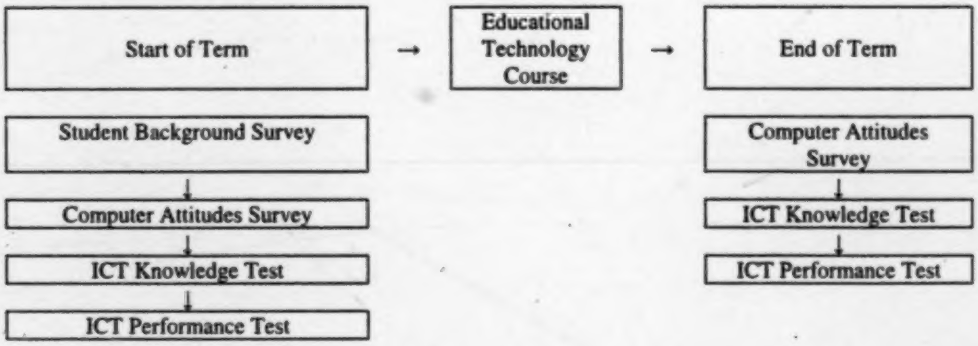
Research Design

This study employed a correlational/ex post facto design, in which certain variables were investigated in retrospect. An experimental design was not used due to the nature of the predictor variables - they were largely historical or impossible/unethical to manipulate (gender, SES, years of computer experience, etc. - see the Independent Variables section further in this document).

Participants were asked to complete four instruments at the start of the university term, prior to taking an educational technology course (see Figure 1). Data related to the independent variables examined in this study were obtained from the pre-course Student Background Survey, the Attitude Survey, and from university student records. The baseline assessment of ICT Literacy was obtained from the pre-course knowledge and performance tests. The pre-course data (which provided a view of student entry ICT Literacy) and its relationship to the post-course data were the focal point of this study.

Attitude, knowledge, and performance were re-assessed after the students had completed the educational technology course. The post-course tests were administered for the benefit of the students (to gauge their progress and prepare for their course final exam) and to obtain some additional insights on student ICT Literacy. However, the educational technology course was not viewed as a "treatment" of focus; this study was not an evaluation of the course.

Figure 1. Research Design


Start of Term
Educational Technology Course
End of Term
Student Background Survey
Computer Attitudes Survey
ICT Knowledge Test
ICT Performance Test
Computer Attitudes Survey
ICT Knowledge Test
ICT Performance Test

Procedures

The students registered in the courses from which participants were drawn had one or more lecture periods with their course professor at the start of the term during which they were introduced to the course and informed of this study. The professor notified the students of the time (first half of their first lab period) and location (course lab facility) of the tests. The course instructors encouraged students to participate by making them aware of the potential benefits to them - the pre-test would be a source of useful advice, and the post-test would serve as a gauge to see how much progress they had made, as well as a review prior to the actual course final exam.

The students completed the pre-test instruments (Student Background Survey, Computer Attitudes Survey, ICT Knowledge Test, and ICT Performance Test) in a campus computer lab facility during the first scheduled lab period of the term for each course section. In each of the two terms there were 10-12 groups (corresponding to scheduled course lab sections) of 20-45 students invited to participate. During all of these periods, the researcher explained the study and supervised the tests. In addition (as noted in the Participants section), a small number of distance students participated from an off-site location. The post-test was administered in a similar way during the last week of classes, before the course final exam. For the post-test, students were not required to repeat filling in the Consent Form or Background Survey, they only completed the Attitude, Knowledge, and Performance instruments.

Instrumentation and Data Collection

Data for this study was collected using the four instruments described below. Additional technical details on the instruments are described in the Instrument Development and Pilot Testing section further below.

1. Student Background Survey

The purpose of this survey (Appendix D) was to collect participant demographic information concerning: (1) general exposure to computers (whether they have a home computer or access to another computer, details on their home computer and Internet setup, how long they have used computers, the types of software they have used) (2) previous education (use of computers in K-12 school, when they graduated high school, location of high school, previous post-secondary computer courses), (3) gender, (4) university program (year of studies, faculty, degree, major, minor, whether they are in an elementary, secondary, or other education program route), and (5) SES (have purchased a home computer, highest schooling of parents). This survey provided data for most of the independent variables in this study, plus additional descriptive information about the students.

This survey was presented to the students as a web-based HTML form. Instructions for answering questions on this form were provided to the students. They were instructed to use the mouse to select the desired value from a set of provided responses or click the mouse in a form field and type in a short answer. When the student clicked the mouse on the submit button at the end of the online form, an Active Server Page (ASP) (Microsoft Corporation, 2000a) process was invoked. This process recorded their responses in a Microsoft Access (Microsoft Corporation, 2000b) database stored on a Windows server and returned a confirmation message to the student's web browser. Only the researcher and thesis supervisor had access to this database.

Instead of traditional paper-based survey forms, this HTML form/ASP process was chosen because it streamlined the process of collecting data and could be programmed to improve the quality of the data. Data were immediately transferred across the campus network into a secure database, ready for statistical analysis. The computerized form was programmed to display warning messages concerning missing or invalid responses. The database was programmed to record additional information in each record such as a date/time stamp and the network address of the participant's computer. A web interface provided the advantage of being viewable on virtually any computer with a web browser and Internet access; this was preferable over specialized software that might not run on certain computers.

2. Computer Attitudes Survey

This instrument (Appendix E) was a questionnaire with twenty Likert-type items, presented to the students as a web-based HTML form similar to the Background Survey. For each question there were five possible responses ranging from Strongly Disagree to Strongly Agree. The response that indicated the greatest negativity towards computer technology received a score of 1 (Strongly Disagree for most questions but Strongly Agree on questions 2, 7, 10, 13, 14, and 18 which had reverse meaning; the scores for the reversed questions were properly adjusted to contribute correctly to the overall score). Scores increased up to 5 for the most positive response. Thus, the maximum score on this instrument was 100, the minimum was 20, and a completely neutral or average response (a score of 3 on each question) was 60.

The commercially available Technophobia Measurement Package (Rosen, Sears, & Weil, 1985, 1988; Sears, Rosen, & Weil, 1985, 1988; Weil & Rosen, 1988), a set of three 20-item instruments, served as a source of ideas for the development of the items in the Computer Attitudes survey. Using the complete Technophobia package would not have suited the needs of this study, as it would have been overwhelming for the participants to fill in three attitude forms in addition to the other instruments implemented in this study. Also, no single one of the Technophobia surveys fulfilled the needs of this study in terms of the content of the items. Upon consulting many research sources including educational technology journals, the ERIC database, Academic Search FullTEXT Elite (EBSCOhost) and the Dissertation Abstracts Database, no other computer attitudes assessment tool was found which suited the needs of this study.

The first set of ten items in the Computer Attitudes survey was intended to measure feelings of self-efficacy towards using computers by asking to what extent the participant felt capable of using a computer or able to do particular tasks (such as use an Internet search tool), whether they enjoyed using computers, and whether they had anxiety about making mistakes or dealing with error messages on the computer.

The second set of ten items was intended to measure general attitudes toward the use of computer technology in education and society. Participants were asked their opinion on how important computer skills are to society, in particular to students and teachers, both in terms of job opportunities and general usefulness. Participants were also asked whether they thought there is an overemphasis on technology in our current society and whether computers are too expensive to put in schools.

3. ICT Knowledge Test

This test was a 28 item multiple-choice test (see Appendix F for a sample) intended to measure declarative knowledge on ICT terminology and concepts. Five possible answers were offered for each question, of which the students were asked to select the one best answer. This instrument was presented to the students as a web-based HTML form and responses were stored in a database as per the above instruments. In addition, responses were compared to the correct answers and the total score was automatically computed and stored in each student's database record. Each response was flagged as either correct (1) or incorrect (0). The computer also recorded in the database the time of day the server sent the form to the student's computer and the time of day that the completed form was returned to the server (a rough measure of the time each participant took to complete each instrument). These are additional advantages of computer based testing over traditional paper-based methods.

The Knowledge Test was divided into seven sections of four items each. The seven sections corresponded to the two remedial and five regular modules included in the curriculum of the recommended educational computing course: (1) Computer Basics, (2) Word Processing, (3) Internet Tools, (4) Digital Media, (5) Computer-Based Presentations, (6) Spreadsheets, and (7) Databases. The course curriculum was developed after an extensive review of the "Processes for Productivity" section of the provincial ICT Program of Studies (Alberta Learning, 2000), and covers all of the major tools in these outcomes. Appendix A provides course outlines for the recommended computing course and the second course from which participants were drawn.

4. ICT Performance Test

This test (see Appendix G for a sample) required the students to complete a number of hands-on computer tasks. Each student was provided with a printed copy of a task list and a set of computer files that they were required to modify. When the student completed the test, these files were then transferred to the database server where they were immediately analyzed by an automated scoring program (described below in Instrument Development and Pilot Testing) and the student's results were stored in the database.

The tasks were a sampling of the practical skills covered in the remedial and regular modules of the recommended educational computing course and were designed to take no more than an hour to complete (see Instrument Development and Pilot Testing/Time Required to Administer Instruments). The tasks were limited to those requiring commonly available software and operating system functions (e.g., text/word processor, spreadsheet, copying/moving files). Other tasks which would have required more specialized software (e.g., animation builder) or hardware (e.g., digital camera), or which might be more time-consuming (e.g., working with video files), were excluded. The practical tasks were divided into three sections (1) basic directory and file management within a graphical user interface (renaming, copying, moving, and deleting files or folders, and creating a simple text file) (2) basic use of a word processor along with general familiarity with operating system and program commands (launching programs/utilities, locating program menu items, looking up file size and modification date, and ascertaining file types), (3) the use of basic features of a spreadsheet application program (modifying font attributes, aligning cells, altering the displayed numeric format of cells, and entering formulas requiring arithmetic operators (e.g., "+" or "*"), functions, relative references, and absolute references).

After completing the tests, students were able to view their profile privately by entering their ID and password on a web-based form. Their Attitude, Knowledge, and Performance total scores were displayed along with the average total score over all of the participants. The profile also displayed detailed information concerning the responses and correct answers to every item on the ICT Knowledge and Performance tests, along with the average score for each item, and the average total for each test sub-section. After the post-test, the profile displayed both the pre-test and post-test information so that the student could assess their progress. A sample student pre-test profile is provided in Appendix H.

Data Analyses

In this study, an alpha level of .05 was used for tests of statistical significance (e.g., correlations or mean differences), unless otherwise stated. The alpha level is an arbitrary value chosen by the researcher as an upper limit for the probability of incorrectly rejecting a true null hypothesis. If the observed significance level of a test was not greater this value, that is $p <= .05$, the null hypothesis was rejected. All statistical calculations in this study were computed using SPSS 10 for Windows (SPSS Inc., 2000).

Instrument Reliability

Reliability of the Attitude Survey, Knowledge Test, and Performance Test were established using internal consistency methods. These methods require only a single administration of an instrument as opposed to other techniques such as test-retest or equivalent forms that would require multiple testing sessions. Cronbach's alpha coefficient was computed for each of these instruments. In the case of the dichotomously coded ICT Knowledge Test, the alpha value is equivalent to the Kuder-Richardson 20 (KR20). As recommended by Fraenkel and Wallen (1996, p.163), a reliability coefficient of at least .70 is desired.

Controlled Variable - Computer Platform

Statistics were computed to determine whether the Computer Platform variable was successfully controlled. The ANOVA (Analysis of Variance) procedure was used to examine the means of ICT Literacy and its sub-scores using Computer Platform as a grouping factor. The Bonferroni post-hoc test (which adjusts the observed significance level to compensate for the fact that multiple comparisons are made) was used to identify whether a significant difference existed between users who previously used Macintosh computers versus those who used Windows computers taking into account that some participants may have used both platforms, some other platform or none of the platforms mentioned on the survey.

Missing Data - General Academic Ability

Statistics were computed to determine whether the available General Academic Ability data was representative of the data for the whole sample, had it been available. In this study, it was not possible to obtain the measure of General Academic Ability for all students. First, the amount of data was limited by the number of students who specifically gave the researcher permission to access their university student records (see Appendix B – Consent Form), in addition to the basic consent given regarding participation in the study. Out of the 713 students who participated in the pre-test, 547 students granted this permission. Another limitation was that a consistent measure of previous academic performance was available in the university's electronic student database only for students currently admitted to the Faculty of Education (as mentioned previously, education students spend part of their program registered in other faculties). The General Academic Ability score (operationalized as Faculty of Education admission GPA) was available for 323 students (i.e., about 59% of those granting permission and 45% of the overall sample). There were no other data easily available in electronic form that would have served as a consistent measure of general academic ability for all students in this study. The researcher was informed by university administrative staff that it would have entailed many hours of manual labor to retrieve such a measure for students not admitted to education because paper records would have to be used. It was not practical for university records staff to perform this work.

Due to this limitation, it was important to ascertain whether the available set of General Academic Ability scores could still be used in statistical calculations (e.g., correlations and regression analysis), or whether it was biased in terms of its effect on the dependent variable, ICT Literacy. It was necessary to determine whether the scores on the components of ICT Literacy (ICT Knowledge and Performance pre-tests) were statistically different for the group of students for whom a measure of General Academic Ability (GEN ACAD) was available in comparison with the group of students for whom it was not available. If a t-test on the comparison of the means of the two groups did not indicate a statistically significant difference (i.e., $p > .05$), if the observed significance level was relatively large, and if the confidence intervals for the mean differences indicated a small effect size for extreme values of the mean differences, then use of the limited set of General Academic Ability scores in the correlations and regression statistics in this study was justified. In other words, this study was seeking acceptance support for the hypothesis that the mean differences were negligible, even though it is theoretically impossible to prove that a null hypothesis is true (Dallal, 2001; Lane, 2001; Norusis, 1995; StatSoft Inc., 2001).

Descriptives

Descriptive statistics (frequency tables or histograms, mean and standard deviation) for all variables were produced. This provided a general picture of the demographics, computer background, and overall ICT achievement of the participants.

Testing Hypotheses on Assessing ICT Literacy

Hypothesis 1 stated that the mean Knowledge and Performance pre-test scores would be significantly lower than an assumed mastery level of 80%. To test this hypothesis, a one-sample t-test was used on the scores, comparing them to the value 80. The observed significance level (p) was divided by two to obtain a one-tailed significance level; this is a correction of p for directional hypotheses (Norusis, 1995). If the t-statistic was significant, then the difference between pre-test scores and the value 80 was assumed to be statistically significant. If, in addition, the mean score was less than 80, then Hypothesis 1 was supported. This process was repeated twice, first for the Knowledge scores and then again for the Performance scores.

Hypothesis 2 stated that Knowledge and Performance post-test scores would be significantly higher than pre-test scores. To test this hypothesis, a one-sample t-test was used on the gain scores (post minus pre), which were calculated for students who completed both the pre and post tests. The gain scores themselves were of practical interest because the mean gain score gives an indication of the magnitude of the change in scores from pre to post. In the t-test, the gain scores were compared to the value zero (this process is equivalent to a dependent or paired samples t-test using the pre and post scores). If the t-statistic was significant (using an adjusted $p/2$ due to the directional hypothesis), then the difference between pre and post scores was assumed to be statistically significant. If, in addition, the mean gain score was positive then Hypothesis 2 was supported. This process was repeated twice, first for the Knowledge scores and then again for the Performance scores.

Testing Hypotheses on Predicting ICT Literacy

First, a correlation matrix was generated to obtain an overview of correlations among the variables. All variables were included in this matrix (categorical variables are coded as binary values to facilitate use in correlation and regression statistics). An $r > .40$ was considered to have theoretical and practical value, and an $r > .65$ was considered extremely important, based on recommendations by Fraenkel and Wallen (1996). At the same time, scatterplots were examined to verify that the correlations were linear.

For an overview of pre-score differences on each of the categorical independent variables (e.g., Gender), the cases were split into two groups based on two levels of the variable and the t-test statistic was used to determine whether the means of the dependent variable for the two groups were significantly different.

Hypotheses 3-5 were tested using a multiple regression procedure similar to the techniques described by Ma (1997) in which variables were entered into the analysis stepwise in hierarchical sets. Multiple regression was highly suitable for this study since it is a procedure that allows one to create a model in which a weighted linear combination of independent variables predict a dependent variable. It serves to identify which independent variables are significantly associated with the dependent variable and to what degree. If the multiple regression procedure resulted in at least one independent variable entering the model then Hypothesis 1 was supported. Hypotheses 4 and 5 concerned the direction of the contribution of individual independent variables in the prediction of ICT Literacy. If a particular variable was selected in the regression model and its regression coefficient was positive, then the section of Hypotheses 4 or 5 relevant to that variable was supported.

Multiple regression is restricted to examining a single dependent variable at a time. Thus, in this study the procedure was run 3 times, once for the composite ICT Literacy scores, and once for each of its sub-scores, Knowledge and Performance. This would effectively determine whether the independent variables are impacting the two aspects of ICT Literacy differently than the overall score.

The multiple regression procedure also requires special handling of categorical independent variables. In order to use categorical variables in a regression analysis, coding must be used to create dummy binary vectors representing the levels of the variable. The number of vectors required for a given variable is one less than the number of levels for that variable (Ma, 1997). Most of the categorical variables used in this study had only two levels so the coding was straightforward: one variable would suffice, with one level assigned the value 0 and the other the value 1. For the original variable Program Route, which had 3 levels, it was necessary to use two dummy variables: NOT ELEM and NOT EDUC (see Independent Variables for the coding used).

The stepwise variable selection method is the most common model building method in multiple regression (Norusis, 1995) and offers the advantage of eliminating redundancies in the final set of predictors, providing a more parsimonious solution, that is, the smallest number of predictors. It is basically a combination of two other methods either of which may not eliminate redundancies as well as the stepwise method: (1) forward selection, in which the model starts with the constant term and at each step adds the variable that results in the largest increase in R^2, subject to the change being large enough to be statistically different than 0 at a preset significance level, and (2) backward elimination, in which you start with a model containing all of the independent variables, and successively eliminate variables that change R^2 the least.

Furthermore, using a hierarchical approach to entering variables into the regression model offers added advantages: (1) the earlier sets of variables entered are statistically controlled, minimizing confounding with the later sets entered, and (2) the regression model is based on a theoretical model of causal priorities in the independent variables. The earlier sets of variables entered are assumed to potentially have a causal effect on the later sets entered, but later sets are presumed not to have a causal effect on earlier sets (Ma, 1997). The theoretical hierarchy used in this study was described in the section Independent Variables.

Testing Hypotheses on Trends in ICT Use in Schools

Hypothesis 6 stated that recent high school graduates started ICT use in school in earlier grades than those who graduated longer ago. To test Hypothesis 6, the correlation between Year of High School Graduation and Earliest Grade of School Computer Use was examined. If the statistic was significant and the correlation was positive, the hypothesis was supported. The degree of support was determined by the magnitude of the correlation coefficient. Hypothesis 7 stated that recent high school graduates had ICT integrated into more high school courses than those who graduated longer ago. Similarly, Hypothesis 7 was tested by examining the correlation between Year of High School Graduation and Number of High School Subjects which Integrated ICT.

Instrument Development and Pilot Testing

The first phase of this research project included the development of the instruments followed by a pilot testing on a small group of students in the Summer 2000 term. This section describes the techniques used to create the instruments, the pilot test participants, and the methods used to assess instrument validity and reliability.

Instrument Technical Features

This section provides a description of the technical features of the computer-based instruments developed in this study. The Background Survey and Knowledge Test were implemented using ASPs written in the VBScript (Microsoft Corporation, 2000e) programming language. The ASP dynamically generated a web page containing an HTML form using question and response data stored in a Microsoft Access 2000 relational database on a Windows server. The Background Survey included a variety of form field types that enabled implementation of different question types: radio button (multiple-choice/single response), drop-down list (multiple-choice/single response with a large set of possible answers), check box (multiple-choice/multiple response), and text box (short answer). The Knowledge Test was composed entirely of multiple-choice questions with five possible radio button answers.

The ASP also inserted client-side JavaScript (Netscape Communications Corporation, 2000) code into these HTML pages for the purpose of quick data validation. When the participant clicked on the form "Submit" button, the JavaScript local editing procedure (executed prior to sending data to the server) was invoked. If unacceptable data were found, the form was not be submitted. For example, the Background Survey asked for the year of high school graduation. Acceptable responses had to be a four-digit year not greater than the current year. If invalid data were found, an error message window was displayed on the screen. Upon acknowledging the error message by clicking on an "OK" button, the participants' display was automatically scrolled to the question where the error was found. The JavaScript procedure also checked to see whether all applicable questions had been answered. If missing responses were found, a warning message window was displayed on the screen. Since it was unethical to demand that the participant answer all questions, the participant was then given the choice to return to the form (scrolled to the first missing response) or to proceed and submit the data. Participant responses were stored in the same database as the question data. The Knowledge Test responses were immediately scored as correct (1) or incorrect (0) by comparing with the correct response stored in the database for each item.

Observations of participants filling in the web-based forms indicated that the JavaScript validation routines contributed to the completeness and accuracy of the data collected. For example, one participant was observed to receive the warning message stating that not all questions were answered. The individual read the warning message, returned to the form, stated "Oops, I missed that question," clicked on a response, and proceeded to submit the form with all questions completed. Another participant reacted similarly upon receiving an error message concerning incorrect data typed into a text field. In all of the Background Survey data collected during the pre-course pilot test (34 participants x 35 questions each for a total of 1190 items) only 1 missing response and no invalid responses occurred. It would have been extremely time-consuming to ensure this level of data completeness and accuracy with paper-based forms. In the corresponding Knowledge Test data (952 items), there were 45 unanswered items, but as in any course exam, these were treated as incorrect responses for the purposes of computing the overall test score. It should be noted that the vast majority of the missing responses (39) occurred with two particular participants who appeared to have tried just the first few questions and then had "given up" (perhaps due to finding the test difficult or being in a hurry to leave) and just submitted the form without checking responses for the remaining questions. In any event, due to this undesirable number of missing responses, some additional messages were added to the Knowledge Test (prior to the Fall session) to ensure that students would be aware that there is no penalty for guessing.

The Performance Test was a much more technically complex instrument than the Knowledge Test since it required automating the analysis of files that participants have manipulated on their local computers. There were many different programming methods which were considered prior to developing this instrument - the decision concerning which tools to use were based on criteria such as time constraints for the initial instrument development, minimizing problems in collecting data, and allowing the Performance Test to occur on either the Windows or Macintosh platform and with varying versions of application software. The solution chosen was to create a Visual Basic for Applications (VBA) (Microsoft Corporation, 2000f) procedure within the same Access database described earlier. Web-based (especially client-side) programming techniques were avoided because of variable client computer setup and security issues involved in attempting to examine files on a client computer over the Internet. This part of the system required uploading a set of files (combined into a single compressed archive) over the Internet to and from each participant's computer and the database server.

During the Performance Test, the VBA procedure was continually running, monitoring a certain file directory every 60 seconds for arriving submissions and executing an automated scoring routine. The VBA scoring procedure implemented programming techniques (e.g., use of Microsoft Automation objects, methods and properties) which enabled automated execution of file system commands (e.g., file searches and directory listings), reading of text stream files, interfacing with external applications (e.g., Microsoft Word and Excel), opening files in these programs, and examining their object hierarchy.

The automated scoring routines were subjected to several iterations of testing and refining. As a first step, the author created about a dozen test cases - sets of computer files representing completed student practical tests - with a mixture of completely correct, partially correct and completely incorrect solutions for each task. These were subjected to the automated routines and the scores for each item of each test case were manually checked for accuracy. This was repeated until all of the test cases were being properly scored. Programming efficiency was also examined and improved until the time required to score the performance test averaged less than a second per test case. These same processes were repeated with the files created by the various expert reviewers who evaluated the system as well as the entire group of student files resulting from the pre-course performance pilot test. Many adjustments to the routines were made as a result of finding in the test data alternative correct or partially correct solutions to certain tasks, and adapting to minor technical differences that arise when computer files are created in different computing environments (e.g., Macintosh versus Windows) or are transferred between different computers.

The procedure that scored the spreadsheet activity of the Performance Test highlights the flexibility in the software used by participants allowed by the programming solution chosen. Spreadsheet files created in Excel 5 and 98 for Macintosh and Excel 95, 97, and 2000 for Windows formats were all scored without technical problems. In addition, the procedure will also work for files created in other programs such as Apple/ClarisWorks or Corel Quattro Pro and saved in an Excel format (most other spreadsheets have built-in Excel converters). It should be noted that the multi-format flexibility assumes that the spreadsheet activities chosen for the test are limited to common features available in the different spreadsheet file formats. Thus, there were no Excel 2000 specific activities used, only common tasks such as basic text or number formatting, cell alignment, and entering formulas. This was found to be adequate for the level of expertise being measured in the target population.

Pilot Test Participants

In order to gather additional evidence of reliability and validity, the instruments were pilot-tested on a small group of undergraduate education students (who were part of the target population) prior to the main data-gathering period. These students were drawn from registrants in two Summer 2000 sections of the recommended educational computing option course. All of the students (35) who attended class on the first day of the term were invited to participate that day. The students were told that the test was completely voluntary, but everyone present in class that day agreed to participate. All 35 students participated, but one student subsequently dropped the course and asked to have their data removed from the study, leaving a total of 34 participants.

The students completed the web-based forms (Consent Form, Background Survey, Attitude Survey, and Knowledge Test) and the practical test that required them to manipulate files on their computer desktop (Performance Test). These tests occurred in a campus lab on Pentium 450 MHz computers with Microsoft Windows 98 and Office 2000 (Microsoft Corporation, 2000c) installed. Students were asked whether any of them preferred to move to a Macintosh computer to do the tests, or fill in paper-based copies of the online forms, but none of them did. Some of the general demographic data on the group is as follows:

a) Gender - 59% female, 41% male.
b) Year of University Studies - 0% First, 9% Second, 24% Third, 35% Fourth, 29% Fifth or higher, 3% Unclassified.
c) Degree Program - 44% B.Ed., 21% B.Ed.(After Degree), 9% in Education combined degrees such as B.Ed./B.A., 18% in other programs such as B.Com. or Open Studies.
d) Education Program Route - 32% Elementary, 44% Secondary, 3% Adult, 21% Other/Not Applicable.
e) Home Location at High School Graduation - 50% university urban area, 0% City 2 urban area, 27% elsewhere in province, 21% outside province.

f) Years Since High School Graduation - median 8, mean 10, minimum 2, maximum 24, SD 5.9. This data item provides a rough approximation of age. If we assume that students graduate high school at age 18, then the average age of this group was 28.

The same group of students was also invited (a week ahead of time) to participate in a post-test, held on the second-last day of the term using the Knowledge and Performance Tests. The students were encouraged to use these tests as a practice and review session prior to their course final exam (held the next day). After completing the test, the students were given a list of answers to the multiple-choice Knowledge Test, computer files providing correct solutions to the Performance Test, and personal help with any questions they had. Discussions with various students after the tests indicated that they were appreciative of this opportunity and that it was good practice for their course final exam. A total of 24 students completed the post-test. Of these 24 students, 23 had also participated in the pre-test, while the remaining student did not attempt the pre-test (registered late in the course and thus did not attend class the first day). Five students who were still included in the pre-test data subsequently dropped the course and thus were not available for the post-test. Six students who did the pre-test and were still registered in the course did not attend class the day of the post-test.

The Consent Form, Background Survey, and Attitude Survey were not repeated for the pilot post-test. The Background Survey was mainly of interest for computing correlations with the pre-test Attitude, Knowledge, and Performance scores; it would not have been an effective use of students' time to have them repeat filling in the Background form during the post-test. Although the Attitude Survey was not repeated for post-test use during the pilot test, it was later decided that it would be of some interest to compare pre and post attitudes. Thus, it was decided to include the Attitude Survey during the subsequent post-tests administered during the Fall/Winter main data gathering periods.

Instrument Validity

A number of activities were completed in order to assess and improve instrument validity including evaluation by various levels of technology experts, obtaining feedback from participants, and computing statistics that offer evidence of validity.

(1) Prior to the pilot testing on summer term students, the content validity of the instruments was independently judged by three individuals with expertise in educational technology: a faculty member, a PhD student, and a senior undergraduate student who had worked for a year as a marker for the recommended educational technology undergraduate course. A number of modifications were made to the instruments based on the feedback from these initial reviewers. For example, some items that were deemed inappropriate were deleted from the instruments, the wording of some items was clarified, computer displays were improved, and new items suggested by the reviewers were added. These reviewers also served to verify that the system was operating without technical errors.

(2) Additional educational technology experts were called upon to similarly review the instruments after the pre-course pilot test (but before the post-course test): A different faculty member, an M.Ed. (Instructional Technology) student, and two students possessing undergraduate degrees who had each worked for two years as teaching/marking assistants for the recommended educational computing course. Additional improvements to the instruments were made as a result of this second round of validation activities.

(3) Feedback on the instruments was obtained from the pilot-test students in a number of ways. First, during the pre-test, the researcher asked the students to raise their hand if at any time during the testing they found any information on the consent form or any question on the instruments to be unclear or inappropriate. A few such questions occurred and were discussed privately with the participant. These inquiries were noted on the researcher's printed copies of the instruments. Second, after reviewing the pre-test data, several students were contacted by email and asked for more information concerning their answers to certain items on the Background Survey. This resulted in some ideas for additional changes to the survey. Third, during the post-test, the students were asked to fill in a short feedback sheet. They were asked whether there were items that they felt were unclear or inappropriate on either the Knowledge or Performance Test, and whether they had any suggestions for additional items that could be included. All of

these sources of student feedback were reviewed and resulted in modifications to the instruments.

(4) After the pre-course pilot test, statistical correlations were computed as indicators of test validity (see Table 3). A high correlation ($r(33) = .460, p<.01$) [1] between the Knowledge Test and Performance Test scores provided evidence of concurrent criterion-related validity. That is, there was logically some commonality in the underlying constructs that these two tests measured. Strong correlations between the course midterm exam (occurred two weeks after pre-test) marks and the pre-test Knowledge ($r(30) = .533, p<.01$) and Performance ($r(30) = .606, p<.001$) scores were evidence of predictive criterion-related validity (the content of the research tests is based on the content of the course, but the course midterm occurred later than the research test).

(5) After the post-course test, additional statistics (shown also in Table 3) were computed. Correlations between the course final exam and the post-tests (run 1 day before the exam) were: Knowledge Test ($r(21) = .409, p = .059$) and Performance Test ($r(23) = .673, p<.001$). The latter correlation was significant and offers strong evidence of concurrent criterion-related validity. The first correlation, while not quite statistically significant at the .05 level ($p=.059$), still offered some evidence of validity. It should be noted that the course exams during the Summer 2000 term were entirely performance-based (although knowledge of certain terms and concepts was implicitly required), thus it was not surprising that the correlations between the course exams were stronger with the Performance Test than with the Knowledge Test. Also, it was easier to obtain some marks by sheer guessing on a multiple-choice test than it was on a performance-based test. Correlations between the course final exam and the pre-tests (run on the first day of class) were: Knowledge Test ($r(28) = .522, p<.01$) and Performance Test ($r(28) = .688, p<.001$). All of these correlations were further evidence of predictive criterion-related validity. Additional correlations showed that most of the pre and post-tests were well associated with the course assignments and course total marks.

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[1] In this notation, r(33) means r(df), where df is the degrees of freedom (equal to n-1)

Table 3. Pilot Test Instrument Validity - Correlation Statistics

	Know Pre	Perf Pre	Know Post	Perf Post	Course MExam	Course FExam	Course Assign	Course Total
Know Pre	1.000	.460**	.556**	.342	.533**	.522**	.506**	.593**
Perf Pre	.460**	1.000	.332	.678**	.606**	.688**	.486**	.707**
Know Post	.556**	.332	1.000	.220	.211	.409	.141	.341
Perf Post	.342	.678**	.220	1.000	.162	.673**	.427*	.543**
Course MExam	.533**	.606**	.211	.162	1.000	.627**	.579**	.804**
Course FExam	.522**	.688**	.409	.673**	.627**	1.000	.592**	.917**
Course Assign	.506**	.486**	.141	.427*	.579**	.592**	1.000	.808**
Course Total	.593**	.707**	.341	.543**	.804**	.917**	.808**	1.000

** Correlation significant at the .01 level   * Correlation significant at the .05 level

Instrument Reliability

The Background Survey was not a scale in which all items contributed to an overall score. Rather than computing internal consistency statistics, reliability of this instrument was established by selective re-testing. Four of the students who had volunteered to participate in the initial instrument evaluation were re-tested using a different format for presenting the questions (as an interview rather than online written questions). No differences in the responses from the two forms were found, indicating high reliability (Fraenkel & Wallen, 1996) although these participants did offer a few suggestions for clarifying the wording of a few items. The consistency of responses was not surprising, since most of the questions on the survey would be considered objective (mainly factual information such as whether or not they own a home computer). Answers to questions like these are likely to be answered the same in a test-retest situation where there is little time between tests.

The reliability of the remaining instruments was established using internal consistency statistics. Cronbach's alpha coefficient was computed for the pre-test Attitude Survey (.63), the Knowledge Test (.79), and the Performance Test (.91). The Attitude Survey reliability was judged too low for meaningful data interpretation (a widely accepted lower limit for alpha is .7), the second was acceptable, and the latter was exceptionally high, being at the level of marketed achievement tests (Fraenkel & Wallen, 1996, p.163).

Improvements to the Attitude Survey were essential to establish solid reliability. Analysis of the inter-item correlation matrix identified three items that were poorly associated with the other items and thus did not contribute well to the overall test score; these items were modified. In addition, since the survey originally consisted of only 12 items, reliability could be easily raised by increasing the number of related items (Fraenkel & Wallen, 1996, p.163). A target of 20 items was established.

The alpha coefficients for the post-test Knowledge Test and Performance Test (run again at the end of term as a post-test) were not as high, .63 and .84 respectively. This was because the tests included some questions deemed by experts to be easy (equivalent to the stated prerequisites for the recommended educational computing course), yet which stumped many students in the pre-test, effectively screening individuals with very low knowledge or practical skills. Tests are not always equally effective in different situations (Murphy & Davidshofer, 1991); these tests were less effective as a post-test after completing a course which covers much of the content of the tests and provides remediation for missing prerequisite skills.

In the pre-course Knowledge Test, no questions (out of 28) were answered correctly by all students. In fact, the easiest question was answered correctly by 88% of students. By contrast, in the post Knowledge Test, there were 4 questions answered correctly by all students, and another 8 questions answered correctly by at least 75% of students. There was less overall variance in the post-test scores than in the pre-test scores. Also, items of zero variance (same score for all students) cannot be correlated with other test items and thus do not enter into the reliability calculations, which reduces the reliability coefficient (a measure of average inter-item correlation).

Not surprisingly, the course appears to have been effective in raising the student scores. The mean pre-to-post gain on the Knowledge Test was 17.52. A one-sample t-test on the gain scores (post – pre), comparing them to a test value of zero (equivalent to a dependent or paired samples t-test using the pre and post scores) found the difference statistically significant. On the Performance pre-test, no questions (out of 24) were answered correctly by all students, while on the post-test, 6 questions were answered correctly by all students. The mean pre-to-post gain on the Performance Test was 26.07;

the one-sample t-test on the gain scores compared to zero found the difference statistically significant. It should, however, be noted that the difference in cases between the pre and post-tests must be considered; the students who didn't participate in both tests were not part of the gain analysis and may have differed from those that did. Another calculation was done in which the missing gains scores were all set to zero; in this case the t-test was still statistically significant for both Knowledge and Performance.

The pre-to-post gains on these two tests affirmed the effectiveness of the instruction and were additional pieces of evidence for the validity of the tests. It demonstrated that participants who have had more training or practice with ICT tools (i.e., the students at post-test time) scored much higher than those with less (i.e., the students at pre-test time). This is logically consistent with what the tests purport to measure.

Time Required to Administer Instruments

The pilot pre-test also served to verify that the instruments could be completed within a reasonable timeframe on a single day. The computer lab periods were three hours long. It was planned (in cooperation with the course instructors) that the testing take no more than half (1.5 hours) of the students' initial lab period to allow time for normal course introductory activities. During the original instrument development, attention was paid to keeping the overall time required to complete all testing to a reasonable level, but after the pilot testing was complete, adjustments could be made. The time required to students to complete all of the forms and tests was approximately 1.5 hours, about 0.5 hour for all of the online forms (consent, attitudes, and knowledge) and 1 hour for the performance tasks.

The start and end time for each participant's work on each online form was stored in the database, making it simple to calculate the average time required to complete a form. In the case of the Background Survey, the average time was about 8 minutes, and the maximum time was 12 minutes. The maximum time required for the 12 Attitude items was around 4 minutes. Thus, increasing the number of items from 12 to 20 would likely make the maximum time for the Attitude Scale around 6 - 7 minutes, which would not be problematic. For the Knowledge Test, the minimum time required was 3 minutes, the maximum 25 minutes, and the average 13 minutes. For the Practical test the minimum time required was 12 minutes, the maximum 65 minutes, and the average 36 minutes.

Pilot Test Statistics

A number of statistics were computed to provide a general picture of the pilot data. Histograms of the pre and post Knowledge and Performance test scores revealed that these distributions were approximately normal, with the post-tests having much higher means and lower variances than the corresponding pre-test. Overall, the achievement on the pre-course tests was quite low with the means of both tests being below 50 (scored out of 100). Comparing the test questions against the recommended educational computing course curriculum and stated prerequisites, the researcher concluded that marginally acceptable course prerequisite skills and knowledge (basic computer operation, file management and word processing) would be indicated by a score of at least 50% on the pre-tests. On the Knowledge Test, 44% of students did not meet this standard and 59% did not meet it on the Performance Test, indicating that many students do not possess adequate course prerequisites. A more comfortable level of prerequisite skills would be indicated by scores of at least 60%. On the Knowledge Test, 77% of students did not reach the 60% level and 71% did not meet it on the Performance Test. On the other end of the spectrum, there were a few students who performed well enough on the pre-test to be likely candidates for successfully challenging the course (and earning an above-average grade) or moving on to other courses that require skills equivalent to completing that course as a prerequisite. Obviously more testing and validity evaluation would be required to establish a standard for this, but in the author's opinion, 80% seems like a level that would reasonably indicate mastery. If this were the case, 3% of students (1 individual in the pilot group) would have qualified. A summary report on the pilot test group performance on the pre-course tests was provided for informational purposes to the course instructors and senior teaching assistants. It should be noted that the stated course prerequisites had not been subjected to rigorous validation testing.

CHAPTER IV: RESULTS

Introduction

This chapter presents the results of this study. First, calculations related to instrument reliability, control of variables, and missing data are presented. This is followed by descriptive information on the data gathered with the various instruments. Finally, statistical analyses related to each of the hypotheses are presented.

Instrument Reliability

Cronbach's alpha coefficient was computed for the Attitude Survey, Knowledge Test, and Performance Test for each of the Fall/Winter Pre/Post testing periods (see Table 4 for the number of cases, items and computed alpha for each test). The alpha for the Attitude Survey ranged from .83 to .89, and for the Performance Test .88 to .96, which established reliability for those two tests. The two Knowledge pre-tests had alphas of .72 and .74, which established reliability as a pre-test. The Fall Knowledge post-test was rated reliable with an alpha of .91. However, the Winter Knowledge post-test had an alpha of only .52, which does not indicate satisfactory reliability. As was found in the pilot testing, this test may have unpredictable reliability as a course post-test because certain questions that differentiate students in the pre-test are answered correctly by a large majority of the students in the post-test (in fact one item was excluded from the alpha computation because it was answered correctly by all students, thus it had zero variance). In addition, a much smaller group of students opted to take the post-test; it is likely that this also affected the results. Cronbach's Alpha is a measure of average inter-item correlation, and correlations are harder to establish with fewer cases or fewer items.

Table 4. Cronbach's Alpha for Fall/Winter Tests

Test Period	**Attitude Survey**			**Knowledge Test**			**Performance Test**		
	Cases	**Items**	**Alpha**	**Cases**	**Items**	**Alpha**	**Cases**	**Items**	**Alpha**
Fall 2000 Pre	363	20	.85	361	28	.72	372	39	.88
Fall 2000 Post	104	20	.89	101	28	.91	85	37	.95
Winter 2001 Pre	311	20	.87	312	28	.74	240	37	.96
Winter 2001 Post	63	20	.83	70	27	.52	50	37	.94

It should be noted that the content of the 20 items on the Attitude Survey was exactly the same for all four test periods while the content of the Knowledge Test and Performance Test items was varied so that the each test period used a different form of the test, but which were as equivalent as possible in level of difficulty. This was done so that if students recorded the answers to one version of the test (e.g., their pre-test) they could not use the answers to methodically complete a subsequent test (e.g., their post-test). As explained previously, after completing the set of tests, the students were provided with correct answers to the multiple-choice questions and a set of file representing correct solutions to the practical tasks. The various versions of tests were parallel in the subsections present, the points for each subsection, and the difficulty ratings of the questions used (based on the pilot test results as well as input from the experts who validated the instruments).

The versions of the Performance test were even more parallel in that virtually the same skills were tested in each comparable question in each version with only a detail such as a file or folder name being changed. For example, Section 2, Question 2 was "Rename folder *B* to *Big*" in one version and "Rename folder *B* to *Bat*" in another version.

Not all questions were different among the versions of the Knowledge and Performance tests. It is interesting to note that even when exact duplicate questions were used, results varied. For example, a question found in Section 2 (Word Processing) of every version of the pre and post Knowledge tests was "What is the CLIPBOARD?". The same set of responses for this question was used each time (except their order was varied). The percentage of students who answered this question correctly for each test was: Fall Term Pre-Test: 67.0%, Fall-Term Post-Test 63.3%, Winter Term Pre-Test 55.8%, Winter Term Post-Test 78.6%. It is curious that during the Fall Term, students were more successful on this question during the Pre-Test than they were during the Post-Test. This same question was also used on the Summer Term Pilot Post-Test and 86.4% of students answered it correctly.

A comparison of the means of the versions of the pre and post Knowledge and Performance tests used in the two terms is provided in Table 5. A statistically significant difference was noted between the Knowledge Pre-Test Fall and Winter versions. Expressed as percentages, the Winter mean was 2.50 % greater than the Fall mean, which is equivalent to 0.7 out of 28 items (i.e., the two tests were within one item of being equivalent in terms of mean number of correct items). Large Ns often facilitate achieving statistical significance (indicating that results from a sample are likely to occur in the population), but in this case it is questionable whether the difference is practically important. As an instructor who frequently has to prepare different versions of exams, the author would not consider such a level of difference between versions to be problematic.

The other significant mean difference noted was between the Fall and Winter Performance Post-Tests. However, due to the extremely parallel content of the various versions of the Performance tests it is more likely than this difference is due to differences in the skill levels of the two groups of participants rather than differences in the test itself.

Table 5. Comparison of Means by Test Version

Version	TERM	N	Mean	SD	Sig.
Knowledge Pre-Test	Fall	361	58.44	15.34	*
	Winter	312	60.94	15.69	
Performance Pre-Test	Fall	372	47.04	19.61	
	Winter	240	47.98	24.18	
Knowledge Post-Test	Fall	101	77.83	9.98	
	Winter	70	77.81	9.84	
Performance Post-Test	Fall	85	76.83	16.14	*
	Winter	50	82.93	12.61	
*** Difference significant at the .05 level**					

Controlled Variable – Computer Platform

The ANOVA (Analysis of Variance) procedure was used to examine the means of the ICT Literacy pre-tests using Computer Platform as a grouping factor. Table 6 lists the mean scores for the various values of Computer Platform and the ANOVA results. For both scores, the omnibus test indicated significant differences: Knowledge *F*(4,668) =

23.712, *p*<.001 and Performance *F*(4,595) = 18.594, *p*<.001. The data show that only a small number of participants had previously used only the Macintosh platform (19 cases and, due to missing data, only 16 cases for the Performance Test). In any event, both test means were lower for Macintosh Only users compared to Windows Only users (but not significant according to the Bonferroni post-hoc test), which supports the conclusion that Macintosh users did not have an advantage on the ICT Literacy tests. The users who clearly scored higher on the tests were those who had previously used both the Macintosh and Windows platforms. The Bonferroni post-hoc test identified significant differences between the "Mac & Win" group compared to each of the other groups. However, this does not point to a bias in the testing, but strongly suggests that users familiar with more than one platform have wider computer experiences, and probably greater ICT Literacy. This is logically consistent with what the tests are attempting to measure, and can be viewed as another source of support for the validity of the tests.

Table 6. ANOVA - Comparison of Means by Computer Platform

(a) Descriptives	**Platform**	**N**	**Mean**	**SD**
KNOWLEDGE PRE-TEST	No OS Used	15	40.48	15.95
	Mac Only	19	49.62	9.81
	Win Only	359	57.23	14.83
	Mac & Win	273	64.98	14.52
	Other OS	7	39.29	11.10
	Combined	673	59.60	15.54
PERFORMANCE PRE-TEST	No OS Used	14	22.80	14.93
	Mac Only	16	42.42	20.49
	Win Only	318	43.05	20.26
	Mac & Win	247	55.16	21.03
	Other OS	5	30.78	15.56
	Combined	612	47.41	21.50

(b) ANOVA		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
KNOWLEDGE PRE-TEST	Between Groups	20176.845	4	5044.211	23.712	.000
	Within Groups	142099.591	668	212.724		
	Total	162276.436	672			
PERFORMANCE PRE-TEST	Between Groups	31137.302	4	7784.326	18.594	.000
	Within Groups	249101.567	595	418.658		
	Total	280238.869	599			

Missing Data – General Academic Ability

It was necessary to determine whether the ICT Knowledge and Performance pre-test scores were statistically different for the group of students for whom a measure of General Academic Ability (GEN ACAD) was available in comparison with the group of students for whom this measure was not available. As shown in Table 7, the means of the two groups were similar for both the Knowledge and Performance pre-tests (the differences were 0.20 and 0.05 respectively). Due to the large sample size, and since this variable was critical to the multiple regression analysis, caution was exercised in declaring these means equivalent. A t-test verified that these differences were indeed not statistically significant (for Knowledge, *p* = .865, for Performance *p* = .976). Although one cannot prove the null hypothesis (Dallal, 2001; Lane, 2001; Norusis, 1995; StatSoft Inc., 2001), that is, one cannot prove that the scores for the two groups are exactly equal, such large *p*-values strongly support the conclusion that the means of the two groups were probably close to equal. There would be an 86.5% probability of error if the null hypothesis were rejected for Knowledge and a 97.6 % probability of error if the null hypothesis were rejected for Performance. These large probabilities provided one source of justification for use of the limited set of General Academic Ability scores in the correlations and regression statistics in this study.

Table 7. Comparison of Means by Availability of General Academic Scores

ICT Pre-Test	GEN ACAD AVAILABLE	N	Mean	SD	p	Mean Diff	Mean Diff Conf. Int. (99%)
KNOWLEDGE	Not Available	364	59.69	15.45	.865	.20	-2.90 to 3.31
	Available	309	59.49	15.67			
	Combined	673	59.60	15.54			
PERFORMANCE	Not Available	331	47.43	21.43	.976	.05	-4.46 to 4.56
	Available	281	47.38	21.63			
	Combined	612	47.41	21.50			

The confidence intervals for the mean differences provided another source of support for accepting that the means were close to equal (Lane, 2001). As shown in Table 7, the 99% confidence interval for the Knowledge mean difference was bounded by the values -2.90 and 3.31. Even if the true Knowledge mean difference were the extreme value 3.31, this would represent a difference of .21 SD, not a large effect. Similarly, the 99% confidence interval for the Performance mean difference was bounded by the values -4.46 and 4.56. Even if the true Performance mean difference were the extreme value 4.56, this would also represent a difference of .21 SD, again not a large effect. Thus, for all practical purposes the means of the two groups were assumed to be equivalent.

Descriptives

This section provides descriptive information concerning the data collected with the Background Survey, Attitude Survey, Knowledge Test, and Performance Test.

Background Survey

The Background Survey was submitted by 713 participants. During one of the first testing sessions in the Fall 2000 term, 12 students who participated did not have their Background Survey responses saved due to a technical problem with the database on the server (adjustments were made, and this problem did not occur in subsequent runs of the tests). Thus, background data was available for 701 participants.

This instrument provided demographic information on the participants as well as data on their previous computer experiences. Details of the frequency of responses to all items in this survey are provided in tabular format in Appendix I. Highlights of the data concerning previous education, previous exposure to computers, gender, university program, and SES of students are provided below:

1. General Computer Exposure:
   a) Home computer (Q1): 87% Yes, 13% No.
   Of those who responded Yes to Q1, responses to Q2 indicated that 86% had a Windows computer, 9% had a Macintosh, and 6% had another type of computer. 5% reported having more than 1 type of computer.
   b) Access to computer at workplace or other household (Q6): 75% Yes, 24% No. Combining the results of Q1 and Q6, 65% answered "Yes" to both questions (indicating two sources of access to a computer other than at university). 97%

answered "Yes" to at least one of the questions (indicating one source of access to a computer other than at university). 3% answered "No" to both questions (indicating that a very small number of students probably had no access to a computer outside of the university).

c) Years of computer use (Q7): 6% started using a computer in 1997 or later, indicating 3 years of use or less, 11% from 1994 – 1996, 34 % from 1990 – 1993, and 47% before 1990. The average was 1989, indicating an average of about 11 years of previous computer use.

d) Application program types used: The most popular choices were: Word Processing (96%), Email (96%), Games (90%), Web Browser (90%), Draw/Paint (65%), Spreadsheet (63%), CD-ROM Reference (60%), Telnet (48%), Database (40%), and Scanning (39%). On average, students indicated that they had previously used 9 different types of application programs.

e) Background Survey questions 9 and 10 provided additional descriptive information concerning participant computer experiences. For specific software titles used, the most popular choices were: Microsoft Word (93%), Netscape (90%), WordPerfect (77 %), Microsoft Internet Explorer (77%), Microsoft Excel (63%), Microsoft Works (61%), Adobe Acrobat Reader (40%), Microsoft PowerPoint (39%), Microsoft Outlook (36%), QuickTime Player (35%), Corel Draw (35%), and AppleWorks/ClarisWorks (34%). On average, students indicated that they had previously used 9 of the specific software programs mentioned. Operating systems were: Windows (93%), Macintosh (43%), MS-DOS (40%), OS/2 (10%), Unix (4%). On average, students indicated that they had previously used 2 of the operating systems mentioned.

2. Previous Education:

a) Earliest grade of school computer use (Q11): 17.6 % first used computers in grade 3 or earlier, 34% in grades 3 – 6, 23% in grades 7 – 9, 15% in grades 10 – 12, 9 % reported never using computers in school. Thus, about 75% of the students had used computers before reaching senior high school (i.e., grade 10).

b) Senior high school subjects which required use of computers (Q12): the most popular choices were: English Language Arts (44%), Social Studies (35%), Computing Science (33%), CTS courses (19%), Biology (18%), and Mathematics (15%). 25% of students reported not being required to use computers in any subjects. On average, students indicated that 2 subjects required use of computers.

c) Year of high school graduation (Q13): 47% graduated in 1997 or later (i.e., within 3 years prior to this test), 25 % from 1994 – 1996, 14 % from 1990 – 1993, and 14% before 1990. The average was 1994; assuming most students graduate high school at about age 18, the average age of the participants was about 24 years.

d) Urban/Rural High School (Q14): 72% Urban, 27% Rural. 49% of students came from the metro urban area in which the university is located. 79% were from the same province.

e) Previous post-secondary credit computer course (Q16): 25% Yes, 74% No. Thus, this was the first computer-related credit course for the majority of students.

f) Previous non-credit computer course/workshop (Q17): 10% Yes, 89% No. Combining the results of Q16 and Q17, 67% had taken neither a credit nor a non-credit post-secondary computer course, 31% had taken either one of the two, 4% had taken both a credit and non-credit course.

3. Gender (Q19): Female 68%, Male 30%, no response 2%
4. University Program:

a) Year of university studies (Q20): First year (9%), Second Year (28%), Third Year (23%), Fourth Year (13%), Fifth Year or more (23%). The median response was Third Year.

b) Faculty (Q21): Education (67%), Arts (12%), Physical Education & Recreation (7%), and Science (5%), 1 - 2 % for each of Business, Native Studies, Agriculture, Open Studies, and Other.

c) Degree Program (Q22): B.Ed. (43%), B.Ed. (After Degree) (22%), B.Ed. Combined (10%), B.A.(10%), B.Sc. (5%). 76% were registered in Education degree programs and 24% were in other degree programs.

d) Program route (Q23): Elementary Education 39%, Non-Elementary Education 52%, Not pursuing an Education degree (7%).

Combining the results of Q22 and Q23, of the students who indicated (in Q22) that they were not currently in an Education degree program, 64% said (in Q23) that they were ultimately pursuing an Education degree.

e) Major (Q24): Science/Technology-related (17%), Other (83%)

f) Minor (Q25): Science/Technology related (19%), Other (81%)

Combining the results of Q21, Q22, Q24, Q25, 32% of students were in a program with some focus on Science/Technology.

5. SES (Highest schooling of either parent, Q15): The median and mode was the 6th highest out of the 9 suggested responses, a 4-year undergraduate degree. Responses were more frequent for values on the higher end of the scale than on the lower end (e.g.,11% had parents who did not achieve a high school diploma, while 20% had parents with some graduate school or higher). This data suggests that on average, the participants had a relatively high SES and that few individuals of very low SES participated in this study.

Attitude Survey

The pre-course Attitude Survey was completed by 686 participants. Of these, a valid total score was calculated for 681 participants, due to missing responses in one or more items on 5 surveys. The mean total score was 70.89, which is 10.89 points above neutral, meaning overall somewhat positive feelings about computer technology. The mean on the Self-Efficacy portion was 32.22 out of 50, and the mean on the Attitude portion was 38.74 out of 50, thus the students' attitudes about the importance of computer technology were higher than their feelings of self-efficacy in actually using computers. Figure 2 provides a graphic representation of the distribution of the pre-test and post-test Attitude total scores. Descriptive statistics and pre-post correlations for the total, self-efficacy, and education/society attitude scores are listed in Table 8. Details on the frequency of responses to individual questions on the pre-course Attitude survey are provided in Appendix J.

Figure 2. Distribution of Attitude Total Scores

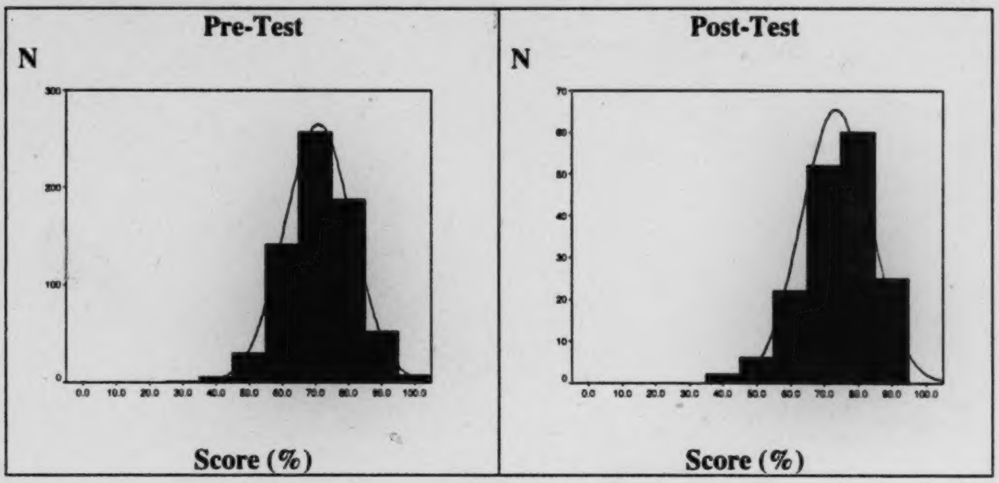


Table 8. Attitude Survey - Descriptive Statistics and Pre-Post Correlations

Variable		N	Mean	SD	Pre/Post r
Attitude Total (out of 100)	**Pre**	681	70.89	10.23	.417
	Post	167	73.39	10.16	**
	Gain (Post-Pre)	133	3.53	7.04	
Self Efficacy (out of 50)	**Pre**	681	32.22	7.39	.497
	Post	170	35.92	6.13	**
	Gain (Post-Pre)	133	4.62	5.11	
Education/Society (out of 50)	**Pre**	681	38.74	5.19	.309
	Post	169	37.53	5.85	**
	Gain (Post-Pre)	133	-1.08	4.11	

N indicates valid cases ** Indicates correlation is significant at the .01 level

In the Self-Efficacy section, questions 6 ("I know the features to look for when purchasing a new computer," mean 2.66), 5 ("I can save a word processing document in different formats such as RTF or plain text," mean 2.69) and 2 ("I often don't know what to do when I get an error message on a computer," mean 2.74) were the only questions with mean scores less than 3. These questions provided some insight into what students felt were their weaknesses. The only item with a mean > 4 was question 8 ("I can use an Internet search tool to find websites related to my interests," mean 4.25); this points to an area of perceived strength. The next highest mean scores were for question 9 ("I use computers for many different purposes," mean 3.72) and question 4 ("I enjoy spending time using computers," mean 3.58). Question 1 ("I am very capable at using computers," mean 3.20) indicated that, overall, the students felt more-or-less neutral, just slightly positive about their computer skills. About 6% of students felt that their skills were very weak, 20% somewhat weak, 29% moderate, 37% somewhat strong, and 8% very strong.

In the Education/Society Attitude section, there were no questions with a mean score less than 3. The highest mean scores were for questions 15 ("Computers help prepare students for the future," mean 4.35), 12 ("In five years everyone will need to know how to operate a computer," mean 4.25), and 17 ("The Internet can be a useful tool in teaching," mean 4.18). These questions provide some insight into the most positive feelings students had concerning the use of computer technology in education and society. Questions 13 ("There is an overemphasis on computer technology in this society," mean 3.06) and 18 ("Using technology in teaching should be optional," mean 3.32) recorded the lowest mean scores. The responses to these two questions may indicate that many participants felt that there may be too much "hype" about the use of computer technology and that teachers shouldn't be "forced" to use it.

The post-course Attitude Survey was completed by 186 participants (of which valid total scores could be calculated for 167), about one-quarter the size of the pre-test group. The significantly lower response rate to the post-course test can be attributed to the fact that the pre-test was held during the first week of lab classes when students were more likely to attend, while the post-test occurred just prior to the end of the term when fewer students find a need to attend classes. Although students were offered the option of submitting the post-course test remotely over the World Wide Web, only 17 students did so; the majority of participants were those who completed the tests in the campus lab.

The mean total score on the Attitude post-test was 73.4, an increase of 2.5 over the pre-test. For participants who completed both the Attitude pre-test and post-test the mean score gain was 3.5. The mean on the post-test Self-Efficacy portion was 35.9, and the mean on the Education/Society Attitude portion was 37.5. As in the pre-test, the students' attitudes about the importance of computer technology were higher than their feelings of self-efficacy in actually using computers. However, the difference between the two sub-scores was not as large as in the pre-test - the mean Self-Efficacy increased while the mean Education/Society Attitude decreased from pre-test to post-test.

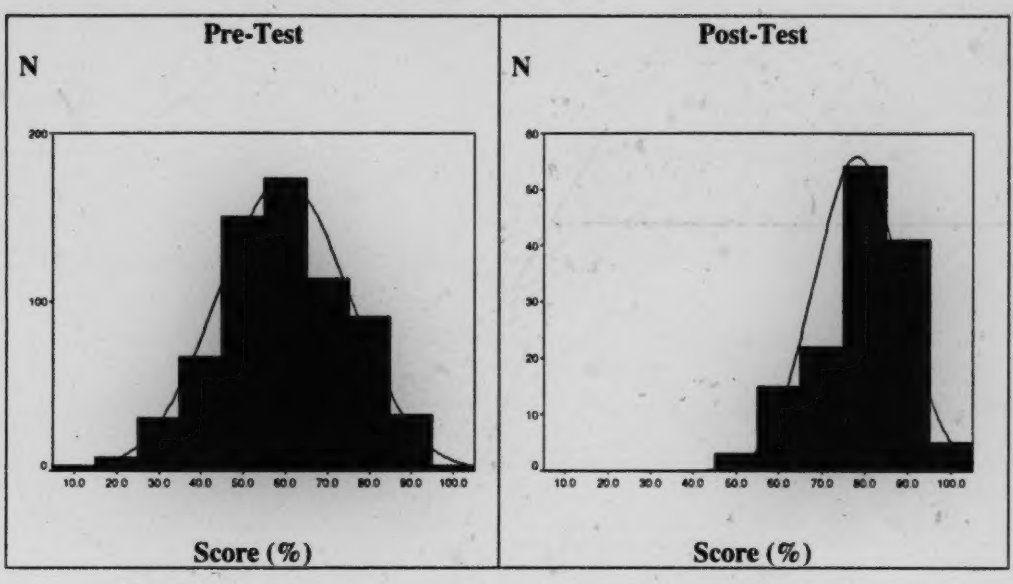
Frequencies of the self-efficacy gain scores also reveal that the vast majority of students increased their computer self-efficacy after taking an educational technology course that focused on learning computer applications. Only 10.5% of the participants who completed both the pre and post Attitude Survey had a negative gain score, 8.3% had a zero gain, and 81.2% had a positive gain score.

The question also arises as to whether there were any significant differences in Attitude Pre-Test scores comparing students who did or did not participate in the Attitude Post-Test (i.e., were participants with more positive computer attitudes more likely or less likely to participate in the post-test?). The mean Self-Efficacy Pre-Test score was 31.63 for those who completed the post-test and 32.34 for those who did not complete the post-test (a difference of 0.71). The mean Education/Society Attitude Pre-Test score was 38.63 for those who completed the post-test and 38.67 for those who did not complete the post-test (a difference of 0.04). Based on the results of t-tests, neither of these differences was significantly different.

Knowledge Test

The pre-course Knowledge Test on computer concepts and terminology was submitted by 673 participants. The distribution of the Knowledge total scores is shown graphically in Figure 3 and descriptive statistics and pre-post correlations are listed in Table 9. The mean total score was 59.60 (expressed as a percentage, i.e., out of 100). About 22% of the participants scored less than 50 on this test, 46% of students scored less than 60, and 9% scored above 80. (These percentages were virtually the same even if the students who reported not pursuing an education degree were excluded: 23%, 47%, and 9%, and the mean was 59.19). These data indicate that many of the students were weak in their knowledge of computer-related concepts and terminology. Since all questions were multiple-choice with five suggested responses, statistically students could score 20/100 on this test by just guessing. The means on the 7 sub-sections of the test indicated that the weakest areas for most students were Digital Media, Databases, and Spreadsheets. Details on the frequency of responses to individual questions on the Knowledge pre-test are provided in Appendix K (Fall Term) and Appendix L (Winter Term).

Figure 3. Distribution of Knowledge Total Scores



The post-course Knowledge Test was submitted by 171 of the participants. The mean total score was 77.82, an increase of 18.22 over the pre-test mean. For the 134 students who completed both the pre and post Knowledge tests, the average gain score (post – pre) was 16.60. A one-sample t-test on the gain scores, comparing them to a test value of zero (equivalent to a dependent or paired samples t-test using the pre and post scores), found the difference statistically significant. No participant scored less than 50 on this test, 6% of students scored less than 60, and 47% scored 80 or more. The post-test means indicated overall improvement in all sections of the test.

The question also arises as to whether there were any significant differences in Knowledge Pre-Test scores comparing students who did or did not participate in the Knowledge Post-Test (i.e., were participants with higher pre-test scores more likely or less likely to participate in the post-test?). The mean Knowledge Pre-Test score was 61.81

for those who completed the post-test and 59.05 for those who did not complete the post-test. Based on the results of a t-test, this difference (2.76) was not significantly different (although the observed $p = .066$ was only slightly away from being significant at the .05 level).

Table 9. Knowledge Test – Descriptive Statistics and Pre-Post Correlations

	Variable		N	Mean	SD	Pre/Post r
	Knowledge Total	**Pre**	673	59.60	15.54	.405 **
		Post	171	77.82	18.80	
		Gain (Post-Pre)	134	16.60	14.19	
1	**Computer Basics**	**Pre**	673	63.00	26.55	.338 **
		Post	179	66.90	28.37	
		Gain (Post-Pre)	134	4.10	28.63	
2	**Word Processing**	**Pre**	673	68.20	24.69	.404 **
		Post	179	70.39	26.95	
		Gain (Post-Pre)	134	4.10	26.41	
3	**Internet**	**Pre**	673	66.23	27.33	.214 **
		Post	179	77.37	25.65	
		Gain (Post-Pre)	134	12.50	29.84	
4	**Digital Media**	**Pre**	673	50.07	28.11	.247 **
		Post	179	73.04	25.34	
		Gain (Post-Pre)	134	25.37	30.19	
5	**Electronic Presentation**	**Pre**	673	61.48	26.40	.110
		Post	179	79.33	24.69	
		Gain (Post-Pre)	134	20.15	27.84	
6	**Spreadsheet**	**Pre**	673	54.53	25.55	.118
		Post	179	71.93	20.97	
		Gain (Post-Pre)	134	20.90	27.11	
7	**Database**	**Pre**	673	53.68	27.01	.256 **
		Post	179	81.42	26.38	
		Gain (Post-Pre)	134	29.10	29.75	

N indicates valid cases
Scores are expressed as percentages (i.e., out of 100)

** Indicates correlation is significant at the .01 level

Performance Test

The pre-course Performance Test, which required the completion of practical computer tasks, was submitted by 612 participants. There were 101 students who completed other parts of the pre-course test (e.g., Background Survey) who did not submit the Performance Test. The most reasonable explanations for the lower level of participation on the Performance part of the pre-course test are that some students did not have time to stay in class for the entire test period or they did not know how to do any of the items on the Performance Test.

If the latter is the true reason for any number of the participants, then the actual overall results of this test are even lower than indicated in the discussion below. A comparison of Knowledge Test results for students who submitted the Performance Test versus students who did not submit the Performance Test also supports the latter reason. There were 89 students who completed the Knowledge Test but did not complete the Performance Test; their mean on the Knowledge Test was 51.2. For the remaining 584 students who did complete the Performance Test, the Knowledge Test mean was 60.9. A t-test revealed that this difference was highly significant (p<.001). Thus, it is highly likely that the students who did not submit the Performance Test would have scored on average lower than those who did submit the Performance Test.

The distribution of the Performance total scores is shown graphically in Figure 4 and descriptive statistics and pre-post correlations are listed in Table 10. The mean total score on the Performance pre-test was 47.41 (expressed as a percentage). About 55% of the participants scored less than 50 on this test, 70% of students scored less than 60, and 7% scored above 80. (These percentages were virtually the same even if the students who reported not pursuing an education degree were excluded: 56%, 72%, and 6%, and the mean was 46.52). These data indicated an overall weakness in computer practical tasks (this part of the test provided virtually no opportunity for guessing). The means (out of 100) on the 3 sub-sections of the test were: (1) File/Folder Management: 75.61, (2) Program/Operating System Usage: 33.57, (3) Spreadsheet: 33.04. Section 1 had generally higher scores - about 14% of participants scored less than 50, 19% of students scored less than 60, and 60% scored above 80. On Section 2, about 69% of participants scored less than 50, 77% of participants scored less than 60, and 7% of participants scored above 80. The results for Section 3 were very similar to Section 2 - about 68% of participants scored less than 50 on Section 3, 76% of participants scored less than 60, and 4% of participants scored above 80. Details on the frequency of responses to individual questions on the Performance pre-test are provided in Appendix M (Fall) and Appendix N (Winter).

Figure 4. Distribution of Performance Total Scores

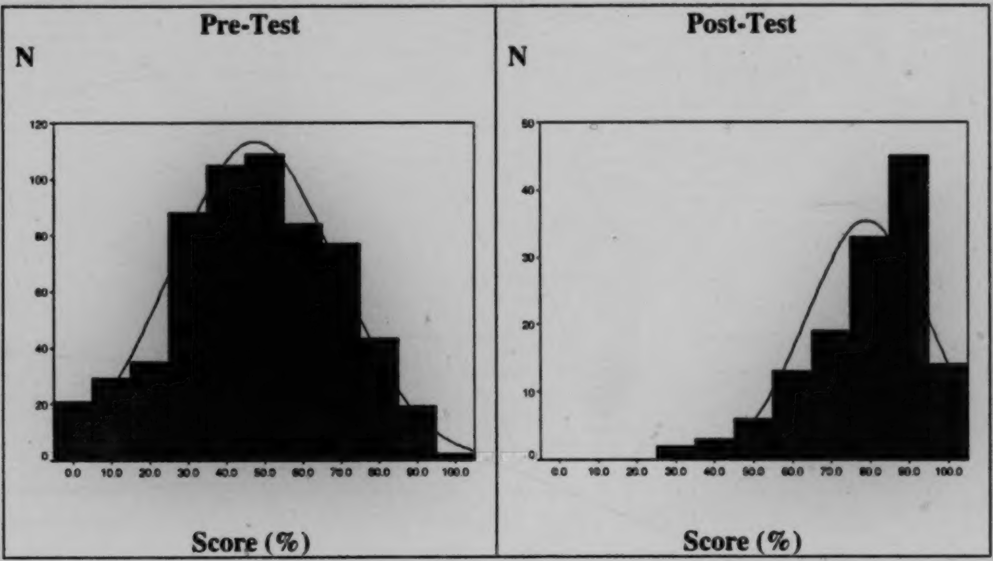


Table 10. Performance Test – Descriptive Statistics and Pre-Post Correlations

	Variable		N	Mean	SD	Pre/Post r
	Performance Total	**Pre**	612	47.41	21.50	.357 **
		Post	135	79.09	15.17	
		Gain (Post-Pre)	103	31.52	18.77	
1	**File/Folder Management**	**Pre**	612	75.61	24.90	.308 **
		Post	135	93.93	10.34	
		Gain (Post-Pre)	103	15.86	20.51	
2	**Program/OS Properties/WP**	**Pre**	612	33.57	28.02	.295 **
		Post	135	63.27	26.62	
		Gain (Post-Pre)	103	30.66	28.36	
3	**Spreadsheet**	**Pre**	612	33.04	26.76	.167
		Post	135	80.06	23.33	
		Gain (Post-Pre)	103	48.04	29.49	

N indicates valid cases
Scores are expressed as percentages (i.e., out of 100)

** Indicates correlation is significant at the .01 level

The post-course Performance Test was submitted by 135 participants. The mean total score was 79.09, an increase of 31.68 over the pre-test mean. For the 103 students who completed both the pre and post Performance tests, the average gain score (post – pre) was 31.52. A one-sample t-test on the gain scores (post – pre), comparing them to a test value of zero (equivalent to a dependent or paired samples t-test using the pre and post scores) found the difference statistically significant. About 8% of the participants scored less than 50 on this test, 12% of students scored less than 60, and 62% scored above 80. The means on the 3 sub-sections of the test were: (1) File/Folder Management: 92.6, an increase of 17 over the pre-test mean (2) Program/Operating System Usage: 62.3, an increase of 28.7 over the pre-test mean (3) Spreadsheet: 78.9, an increase of 45.9 over the pre-test mean. Section 1 had the highest scores – only 2% of participants scored less than 70, and 94% scored above 80. On Section 2, about 24% of participants scored less than 50, 40% of participants scored less than 60, and 31% of participants scored above 80. On Section 3, about 11% of participants scored less than 50, 17% of participants scored less than 60, and 64% of participants scored above 80.

The question also arises as to whether there were any significant differences in Performance Pre-Test scores comparing students who did or did not participate in the Performance Post-Test (i.e., were participants with higher pre-test scores more likely or less likely to participate in the post-test?). The mean Performance Pre-Test score was 49.18 for those who completed the post-test and 47.01 for those who did not complete the post-test. Based on the results of a t-test, this difference (2.17) was not significantly different ($p = .337$).

ICT Literacy Composite Score

Composite scores were computed as the mean of the Knowledge and Performance z-scores to obtain an overall measure of ICT Literacy for use in data analyses. The z-scores were used instead of the raw Knowledge and Performance test scores because the variances of the Knowledge and Performance distributions were different; a mean calculated on the raw scores would have produced a biased distribution of composite scores. Using z-scores allows one to examine comparable distributions, each with a mean of 0 and a standard deviation of 1. The composite scores were calculated for 701 pre-test participants and 172 post-test participants. In some cases, only one of the Knowledge or Performance score was available (due to missing data). In these cases, the composite score (mean z-score) was set to the available z-score. This was equivalent to estimating the missing z-score based on the available z-score, which is justified due to the fact that the Knowledge and Performance pre-test scores had a relatively high correlation (*r*(583) = .550, *p*<.001), as shown in Table 11).

In the pre-test data, there were 28 cases where the Knowledge scores were missing and another 89 cases where the Performance score was missing. In the post-test data, there was 1 case where the Knowledge scores were missing and another 35 cases where the Performance score was missing. The ICT Literacy score was coded as missing if both Knowledge and Performance scores were unavailable for a particular student.

Testing Hypotheses

Assessing ICT Literacy

Hypothesis 1 stated that the mean Knowledge and Performance pre-test scores would be significantly lower than an assumed mastery level of 80%. The means were Knowledge: 59.60 and Performance: 47.41. The t-tests found both of these values significantly lower than 80 (two-tailed $p < .001$, adjusted one-tailed $p/2$ also $< .001$, for both). Thus, Hypothesis 1 was supported.

Hypothesis 2 stated that Knowledge and Performance post-test scores would be significantly higher than pre-test scores. For students who completed both the pre and post Knowledge tests, the average gain (post – pre) was 16.60 (equivalent to 1.07 pre-test SD). A t-test found the difference statistically significant (two-tailed $p < .001$, adjusted one-tailed $p/2$ also $< .001$, for both). For students who completed both Performance tests, the average gain score (post – pre) was 31.52 (equivalent to 1.47 pre-test SD). A t-test found the difference statistically significant. Thus, Hypothesis 2 was supported.

Correlations with ICT Literacy

To obtain an initial view of relationships in the data, a correlation matrix (Table 11) was generated. This matrix served to identify variables that might be associated with individual differences in the ICT Composite, Knowledge, or Performance pre-test scores. The variables VAR APP (Number of software applications used) and SELF EFF (the Self-Efficacy portion of the Attitude Survey) were the most positively correlated with the ICT pre-test scores with correlations ($r(688) = .581, p<.001$) and ($r(677) = .532, p<.001$) respectively. YR USE (years of computer use), SCH SUBJ (number of high school subjects that integrated computers), and YR SCH USE (years of K-12 use of computers) were correlated to a lesser degree with ICT test scores. YR GRAD (year of high school graduation) and ED SOC (Attitude Survey part two - attitude towards computers in education and society) were somewhat correlated with Performance but much less with Knowledge. GEN ACAD (General Academic Ability) was somewhat correlated with Knowledge, but not with the Performance. ED PAR (Education of Parents) was not very highly correlated with either of the dependent sub-scores in this study.

There were other correlations worth noting. The two dependent pre sub-scores KNOW PRE (Knowledge Pre-Test) and PERF PRE (Performance Pre-Test) were highly correlated ($r(583) = .550, p<.001$) as were the two post sub-scores KNOW POST (Knowledge Post-Test) and PERF POST (Performance Post-Test) ($r(135) = .518, p<.001$). The pre-scores were also somewhat correlated with the corresponding post scores: KNOW PRE/KNOW POST ($r(133) = .405, p<.001$), PERF PRE/PERF POST ($r(112) = .350, p<.001$), and ICT composite scores ICT PRE/ICT POST ($r(143) = .466, p<.001$). SELF EFF (the Self-Efficacy portion of the Attitude Survey) was highly correlated with VAR APP (Number of application program types used) ($r(684) = .701, p<.001$). Thus, a person's feelings of self-efficacy towards using computers appears to be highly influenced by gaining experience with a greater number of different computer software applications. SELF EFF was also somewhat correlated with ED SOC (the second part of the Attitude Survey - attitude towards computers in education and society), SCH SUBJ (number of high school subjects that integrated computers), YR USE (years of computer use), and YR SCH USE (number of years of K-12 school-based use of computers).

Table 11. Bivariate Correlations Between Variables
(continued on next page)

Variables		KNOW PRE	PERF PRE	ICT PRE	KNOW POST	PERF POST	ICT POST	HOME COMP	OTH COMP	CRED COUR	NON CRED	URB	AFT DEG
KNOW PRE		1.000	.550**	.900**	.405**	.302**	.420**	.197**	.073	.210**	.018	.007	.037
	N	673	584	673	134	112	135	673	669	671	669	668	669
PERF PRE		.550**	1.000	.890**	.302**	.350**	.379**	.136**	.108**	.154**	.029	-.009	-.064
	N	584	612	612	132	113	133	599	595	593	591	592	591
ICT PRE		.900**	.890**	1.000	.413**	.387**	.466**	.196**	.099**	.209**	.008	-.003	-.009
	N	673	612	701	143	118	144	688	683	682	680	680	680
KNOW POST		.405**	.302**	.413**	1.000	.518**	.907**	.089	.089	.153	.101	.031	.218*
	N	134	132	143	171	136	171	140	139	138	138	139	137
PERF POST		.302**	.350**	.387**	.518**	1.000	.884**	.029	-.112	-.023	.027	-.045	.066
	N	112	113	118	136	137	137	115	115	114	114	114	113
ICT POST		.420**	.379**	.466**	.907**	.884**	1.000	.117	.081	.107	.087	-.016	.187*
	N	135	133	144	171	137	172	141	140	139	139	140	138
HOME COMP		.197**	.136**	.196**	.089	.029	.117	1.000	.014	.011	.099**	.084*	-.024
	N	673	599	688	140	115	141	700	695	693	691	691	690
OTH COMP		.073	.108**	.099**	.089	-.112	.081	.014	1.000	.052	-.022	-.063	.011
	N	669	595	683	139	115	140	695	695	689	687	687	686
CRED COUR		.210**	.154**	.209**	.153	-.023	.107	.011	.052	1.000	.081*	.073	.085*
	N	671	593	682	138	114	139	693	689	693	691	690	690
NON CRED		.018	.029	.008	.101	.027	.087	.099**	-.022	.081*	1.000	.042	.104**
	N	669	591	680	138	114	139	691	687	691	691	688	689
URB		.007	-.009	-.003	.031	-.045	-.016	.084*	-.063	.073	.042	1.00	.064
	N	668	592	680	139	114	140	691	687	690	688	691	687
AFT DEG		.037	-.064	-.009	.218*	.066	.187*	-.024	.011	.085*	.104**	.064	1.00
	N	669	591	680	137	113	138	690	686	690	689	687	690
FOC TECH		.192**	.197**	.204**	.095	.147	.159	.038	.040	.116**	.096*	-.023	-.002
	N	658	579	667	130	106	131	676	672	676	675	673	676
NOT ELEM		.089*	.114**	.117**	.070	.074	.083	.044	-.016	.157**	-.018	.094*	.032
	N	666	587	675	135	112	136	684	680	684	683	681	684
NOT EDUC		.128**	.172**	.161**	.164	.106	.158	.085*	.075	.150**	.042	.100**	-.147**
	N	666	587	675	135	112	136	684	680	684	683	681	684
GEND MALE		.118**	.137**	.143**	.045	.200*	.091	.003	-.045	.169**	.020	.071	.046
	N	666	589	677	136	112	137	687	683	687	686	684	687
YR USE		.230**	.194**	.249**	.146	.095	.158	.072	.064	.149**	.082*	-.036	.179**
	N	667	597	681	139	114	140	693	689	687	685	685	684
VAR APP		.519**	.542**	.581**	.250**	.254**	.293**	.219**	.199**	.188**	.048	-.034	-.087*
	N	673	600	689	140	115	141	700	695	693	691	691	690
YR SCH USE		.134**	.209**	.191**	.116	.042	.091	.077*	.080*	-.046	-.103**	-.062	-.228**
	N	665	593	679	140	115	141	690	686	684	682	682	681
SCH SUBJ		.153**	.214**	.202**	.061	.063	.094	.061	.139**	-.131**	-.110**	-.088*	-.266**
	N	673	600	689	140	115	141	700	695	693	691	691	690
YR GRAD		.024	.201**	.118**	.033	-.025	.015	-.030	.067	-.076*	-.290**	-.064	-.357**
	N	672	596	685	139	114	140	697	693	693	691	691	690
GEN ACAD		.152**	.006	.106	.079	-.030	.035	-.055	.124*	.048	.071	-.099	.167**
	N	309	281	316	79	62	79	323	321	320	320	320	319
ED PAR		.035	.022	.024	-.039	.018	-.024	-.022	.043	-.016	-.021	.048	.093*
	N	667	592	679	139	114	140	690	686	689	687	687	686
SELF EFF		.482**	.476**	.532**	.272**	.204*	.316**	.262**	.209**	.182**	.067	-.003	-.036
	N	673	589	678	136	112	137	685	681	683	681	680	681
ED-SOC		.093*	.126**	.115**	.100	.070	.066	.105**	.126**	-.012	.101**	.035	-.066
	N	673	589	678	136	112	137	685	681	683	681	680	681

** Correlation significant at the .01 level   * Correlation significant at the .05 level

Table 11. Bivariate Correlations Between Variables (continued)

Variables	FOC TECH	NOT ELEM	NOT EDUC	GEND MALE	YR USE	VAR APP	YR SCH USE	SCH SUBJ	YR GRAD	GEN ACAD	ED PAR	SELF EFF	ED SOC
KNOW PRE	.192**	.089*	.128**	.118**	.230**	.519**	.134**	.153**	.024	.152**	.035	.482**	.093*
N	658	666	666	666	667	673	665	673	672	309	667	673	673
PERF PRE	.197**	.114**	.172**	.137**	.194**	.542**	.209**	.214**	.201**	.006	.022	.476**	.126**
N	579	587	587	589	597	600	593	600	596	281	592	589	589
ICT PRE	.204**	.117**	.161**	.143**	.249**	.581**	.191**	.202**	.118**	.106	.024	.532**	.115**
N	667	675	675	677	681	689	679	689	685	316	679	678	678
KNOW POST	.095	.070	.164	.045	.146	.250**	.116	.061	.033	.079	-.039	.272**	.100
N	130	135	135	136	139	140	140	140	139	79	139	136	136
PERF POST	.147	.074	.106	.200*	.095	.254**	.042	.063	-.025	-.030	.018	.204*	.070
N	106	112	112	112	114	115	115	115	114	62	114	112	112
ICT POST	.159	.083	.158	.091	.158	.293**	.091	.094	.015	.035	-.024	.316**	.086
N	131	136	136	137	140	141	141	141	140	79	140	137	137
HOME COMP	.038	.044	.085*	.003	.072	.219**	.077*	.061	-.030	-.055	-.022	.262**	.105**
N	676	684	684	687	693	700	690	700	697	323	690	685	685
OTH COMP	.040	-.016	.075	-.045	.064	.199**	.080*	.139**	.067	.124*	.043	.209**	.128**
N	672	680	680	683	689	695	686	695	693	321	686	681	681
CRED COUR	.116**	.157**	.150**	.169**	.149**	.188**	-.046	-.131**	-.076*	.048	-.016	.182**	-.012
N	676	684	684	687	687	693	684	693	693	320	689	683	683
NON CRED	.096*	-.018	.042	.020	.082*	.048	-.103**	-.110**	-.290**	.071	-.021	.067	.101**
N	675	683	683	686	685	691	682	691	691	320	687	681	681
URB	-.023	.094*	.100**	.071	-.04	-.034	-.062	-.088*	-.064	-.099	.048	-.003	.035
N	673	681	681	684	685	691	682	691	691	320	687	680	680
AFT DEG	-.002	.032	-.147**	.046	.179**	-.087*	-.228**	-.266**	-.357**	.167**	.093*	-.036	-.066
N	676	684	684	687	684	690	681	690	690	319	686	681	681
FOC TECH	1.000	.378**	.112**	.158**	.046	.154**	.013	.060	-.012	-.145*	-.059	.152**	.032
N	676	673	673	674	670	676	667	676	676	312	673	670	670
NOT ELEM	.378**	1.000	.223**	.315**	.013	.122**	-.018	.019	.028	-.051	-.034	.116**	-.056
N	673	684	684	681	678	684	675	684	684	317	680	677	677
NOT EDUC	.112**	.223**	1.000	.130**	-.06	.187**	.015	.039	.095*	.010	-.081*	.167**	.067
N	673	684	684	681	678	684	675	684	684	317	680	677	677
GEND MALE	.158**	.315**	.130**	1.000	.107**	.120**	-.066	-.067	-.066	-.072	-.021	.135**	-.024
N	674	681	681	687	681	687	678	687	687	317	683	678	678
YR USE	.048	.013	-.049	.107**	1.0	.293**	.327**	.045	-.062	.072	.048	.255**	.065
N	670	678	678	681	693	693	684	693	691	322	686	679	679
VAR APP	.154**	.122**	.187**	.120**	.293**	1.000	.337**	.369**	.209**	-.035	.023	.701**	.185**
N	676	684	684	687	693	701	690	701	697	323	690	685	685
YR SCH USE	.013	-.018	.015	-.066	.327**	.337**	1.00	.495**	.641**	-.096	.139**	.230**	.060
N	667	675	675	678	684	690	690	690	688	320	681	676	676
SCH SUBJ	.060	.019	.039	-.067	.045	.369**	.495**	1.000	.503**	-.220**	.089*	.260**	.117**
N	676	684	684	687	693	701	690	701	697	323	690	685	685
YR GRAD	-.012	.028	.095*	-.066	-.06	.209**	.641**	.503**	1.000	-.216**	.124**	.106**	-.042
N	676	684	684	687	691	697	688	697	697	323	690	684	684
GEN ACAD	-.145*	-.051	.010	-.072	.072	-.035	-.096	-.220**	-.216**	1.000	.025	-.006	.058
N	312	317	317	317	322	323	320	323	323	323	319	315	315
ED PAR	-.059	-.034	-.081*	-.021	.048	.023	.139**	.089*	.124**	.025	1.00	-.048	-.023
N	673	680	680	683	686	690	681	690	690	319	690	679	679
SELF EFF	.152**	.116**	.167**	.135**	.255**	.701**	.230**	.260**	.106**	-.006	-.048	1.000	.270**
N	670	677	677	678	679	685	676	685	684	315	679	685	685
ED-SOC	.032	-.056	.067	-.024	.065	.185**	.060	.117**	-.042	.058	-.023	.270**	1.000
N	670	677	677	678	679	685	676	685	684	315	679	685	685

** Correlation significant at the .01 level   * Correlation significant at the .05 level

Comparisons of Group Means

Comparisons of group means (using the t-test for independent samples) were then calculated to gain further information concerning categorical variables that might be associated with individual differences in ICT pre-test scores (see Table 12). The largest mean differences were observed in the following variables: HOME COMPUTER, PGM FOCUS (those whose major/minor/degree was science/technology/math related scored higher), PREV CREDIT COURSE (those who previously took a post-secondary credit course related to computers scored higher), GENDER (males scored higher), and ACCESS OTHER COMPUTER (those who had access to another computer scored higher).

Regarding the variable PGM ROUTE, comparing students on an elementary education route versus those on a secondary/adult/other education route (and excluding students who stated that they were not ultimately pursuing an education degree) did not result in a significant mean difference. However, comparing all students pursuing an education degree with the relatively small group of apparently non-education students (those in other faculties who were taking the educational technology courses from which the sample was drawn but stated that they were not aiming at an education degree) produced a relatively large and significant mean difference, especially on the Performance score (14.82). However, the portion of the sample that represented students not pursuing an education degree was relatively small (47 cases, 6.7 % of the sample), so these results may not be valid; this study would need to be replicated including a larger number of non-education students in the sample.

The remaining variables, URBAN/RURAL, PREV NON-CREDIT COURSE, and POST-SEC EXP (regular undergraduates in first to fourth year versus students in after-degree/fifth year or more who have greater post-secondary experience/maturity) did not appear as highly associated with differences in ICT scores, based on this preliminary analysis.

Table 12. Comparison of Knowledge and Performance Pre-Test Group Means

		Knowledge Pre-Test					Performance Pre-Test				
Categorical Variable	**Level**	**N**	**Mean**	**SD**	**Mean Diff**	**Sig**	**N**	**Mean**	**SD**	**Mean Diff**	**Sig**
Home Computer	**Yes**	589	60.76	15.31	9.27	.000	532	48.54	21.76	9.35	.000
	No	84	51.49	14.76			67	39.19	18.52		
Access Other Computer	**Yes**	504	60.21	15.63	2.64	.059	446	48.80	20.82	5.35	.009
	No	165	57.58	15.17			149	43.45	23.28		
Urban/Rural	**Urban**	488	59.80	15.21	.26	.850	434	47.55	22.24	-.46	.819
	Rural	180	59.54	16.19			158	48.01	19.92		
Prev Credit Course	**Yes**	167	65.31	14.07	7.50	.000	152	53.30	21.66	7.62	.000
	No	504	57.81	15.46			441	45.68	21.31		
Prev Non-Credit Course	**Yes**	65	60.55	16.38	.94	.643	58	49.59	23.36	2.13	.477
	No	604	59.61	15.32			533	47.46	21.43		
Gender	**Female**	456	58.40	15.18	-3.93	.002	405	45.64	20.93	-6.39	.001
	Male	210	62.33	15.82			184	52.02	22.69		
Post-Sec Exp	**AD**	194	60.53	14.99	1.27	.334	179	45.48	21.84	-3.03	.118
	Reg	475	59.26	15.64			412	48.51	21.55		
Pgm Route	**Ed Elem**	266	58.04	14.99	-2.00	.108	235	44.50	20.15	-3.54	.054
	Ed Not-Elem	353	60.05	15.63			312	48.04	22.01		
Pgm Route	**Not-Educ**	47	66.87	13.69	7.68	.001	40	61.34	22.86	14.82	.000
	Educ	619	59.19	15.37			547	46.52	21.28		
Pgm Focus	**Science/Tech**	218	63.83	14.87	6.31	.000	192	53.55	22.04	9.09	.000
	Other	440	57.52	15.38			387	44:47	20.95		

Multiple Regression Analysis

A multiple regression analysis was performed to test Hypotheses 3-5 and determine which independent variables best predict the pre-test composite ICT Literacy scores, as well as the Knowledge and Performance sub-scores. The following results indicate support for Hypothesis 3. That is, there is a linear combination of variables that significantly predict ICT Literacy and its sub-scores.

The stepwise method of entering variables was used with the following options: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100, cases excluded pairwise (to minimize loss of date due to missing values in some variables). The significance level for entering variables must be less than the significance level for removing variables to prevent an endless loop in which the same variable is entered and removed over and over again. Seven hierarchical sets of variables as described earlier were used in the entering process.

Table 13. Regression Model Summary

Dependent Variable	Set	Step	Variable Entered	R	R^2	Chg R^2	Final Std Beta Coeff
ICT Pre Composite	Constant						–2.950
	1. Individual Char.	1	GEND MALE	.143	.021	.021	.054
	2. Family/SES	2	HOME COMP	.243	.059	.038	.061
	3. K-12 Educ.	3	SCH SUBJ	.315	.099	.040	.047
	4. Acad. Ability	4	GEN ACAD	.361	.130	.031	.151
	5. Post-Sec. Educ.	5	CRED COURSE	.415	.172	.042	.078
		6	SC/TECH	.447	.199	.027	.115
	6. Overall Exp.	7	VAR APP	.624	.390	.190	.374
	7. Comp. Attitudes	8	SELF EFF	.640	.410	.020	.204
ICT Knowledge Pre	Constant						7.685
	1. Individual Char.	1	GEND MALE	.118	.014	.014	.035
	2. Family/SES	2	HOME COMP	.230	.053	.039	.080
	3. K-12 Educ.	3	SCH SUBJ	.274	.075	.022	.027
	4. Acad. Ability	4	GEN ACAD	.346	.120	.044	.191
	5. Post-Sec. Educ.	5	CRED COURSE	.401	.161	.041	.088
		6	SC/TECH	.433	.188	.027	.120
	6. Overall Exp.	7	VAR APP	.581	.338	.150	.329
	7. Comp. Attitudes	8	SELF EFF	.596	.355	.017	.185
ICT Performance Pre	Constant						-895.97
	1. Individual Char.	1	GEND MALE	.137	.019	.019	.052
	2. Family/SES	2	HOME COMP	.193	.037	.019	.010
	3. K-12 Educ.	3	SCH SUBJ	.290	.084	.047	.032
		4	YR GRAD	.314	.099	.015	.128
	5. Post-Sec. Educ.	5	SC/TECH	.354	.125	.027	.104
		6	CRED COURSE	.382	.146	.021	.036
	6. Overall Exp.	7	VAR APP	.569	.324	.178	.371
	7. Comp. Attitudes	8	SELF EFF	.583	.339	.016	.179

Table 13 provides the Regression model summary, which lists the final set of variables selected in each analysis (i.e., those variables that passed the test of significance at each step). R is the coefficient of multiple correlation, which indicates the strength of the correlation between the linear combination of independent variables with the dependent variable. R^2 represents the total amount of variance in the dependent variable accounted for by the entire model at each step. Chg R^2 represents the amount of increased variance accounted for by each variable entered; this is the best measure of the relative importance of each variable. The Final Standardized Beta Coefficient is the weighting of each independent variable (expressed as a z-score to allow more proper comparison of variables) after the final step. A regression equation could be written using the identified constant and these coefficients (e.g., $Y_{ICTPRE} = -2.950 + .054$ GENDMALE + .061

HOMECOMP, + ...) The sign of the beta coefficient indicates the direction of the variable's contribution in the prediction (i.e., negative or positive). However, the magnitude of the coefficient does not indicate in any absolute sense the relative importance of a particular independent variable (Norusis, 1995). Chg R^2 is indicative of the relative importance of each variable and will be the focus of the data analysis.

For the dependent variable ICT Pre-Test Composite, at least one independent variable from each set and a total of 8 variables entered the model. The final R was .640, meaning that the combination of independent variables selected have a rather high correlation with ICT Literacy (Fraenkel & Wallen, 1996). R^2 after the final step was .410, meaning that this model explains 41% of the total variance in ICT achievement, an amount considered to be very meaningful in behavioral sciences (Cohen & Cohen, 1983). According to the model the amount of variance accounted for by each set is: (1) Individual Characteristics (Gender) 2.1%, (2) Family/SES (Home Computer) 3.8%, (3) K-12 Education (High School Subjects using ICT) 4.0%, (4) Academic Ability 3.1%, (5) Post-Secondary Education (Previous Credit Computer Course and Program Focus on Science/Math/Technology) 6.9%, (6) Overall Computer Exposure (Variety of Applications Used) 19.0%, and (7) Computer Attitudes 2.0%. All of the beta coefficients for the selected variables were positive, meaning that the contributions of these variables were all positive. This provides support for the statements in Hypotheses 2 and 3 relative to the variables selected, but does not support the statements relative to the variables not selected. The strongest predictor was Overall Computer Exposure/Variety of Applications Used. This is not surprising, as the count of the number of software applications a student has used may be thought of as a rough measure of ICT Literacy in itself.

Similar results were obtained in the regression analysis for the Knowledge variable. The same variables entered the Knowledge model as entered the Composite model. However, the amount of variation explained by Individual Characteristics, K-12 Education, Post-Secondary Education, Overall Exposure, and Attitudes were somewhat lower, while the impact of Family/SES and Academic Ability were both somewhat higher. The Knowledge regression model accounted for 35.5% of the variance in ICT

Knowledge, which is lower than the level of explanation achieved in the ICT Composite model.

The results for Performance had some differences compared to the Composite and Knowledge analyses. First, Academic Ability did not enter into the model. Second, two K-12 Education variables (SCH SUBJ and YR GRAD) entered the model. The Performance regression model accounted for 33.9% of the variance in ICT Performance, which is lower than the level of explanation achieved in the ICT Composite and Knowledge models. The variation accounted for by the individual variables was generally lower than in the other models as well.

Trends in ICT Use in Schools

Hypothesis 6 was tested by examining the correlation between YR GRAD (Year of High School Graduation) and SCH USE (the number of years since participant's first use of computers in school; higher values indicate earlier first use). As per Table 11, the correlation was high ($r(687) = .641$, $p<.001$) and statistically significant, thus Hypothesis 6 is supported. This provides supports for the hypothesized trend that students who graduated from high school more recently started ICT use in school in earlier grades than those who graduated longer ago.

Hypothesis 7 was tested by examining the correlation between YR GRAD and SCH SUBJ (the number of high school subjects participant took in which ICT was integrated). As per Table 11, the correlation was high ($r(696) = .503$, $p<.001$) and statistically significant, thus Hypothesis 7 is supported. This provides support for the hypothesized trend that students who graduated high school more recently had ICT integrated into more high school courses than those who graduated longer ago. However, this trend appears to be weaker than the trend related to Hypothesis 6.

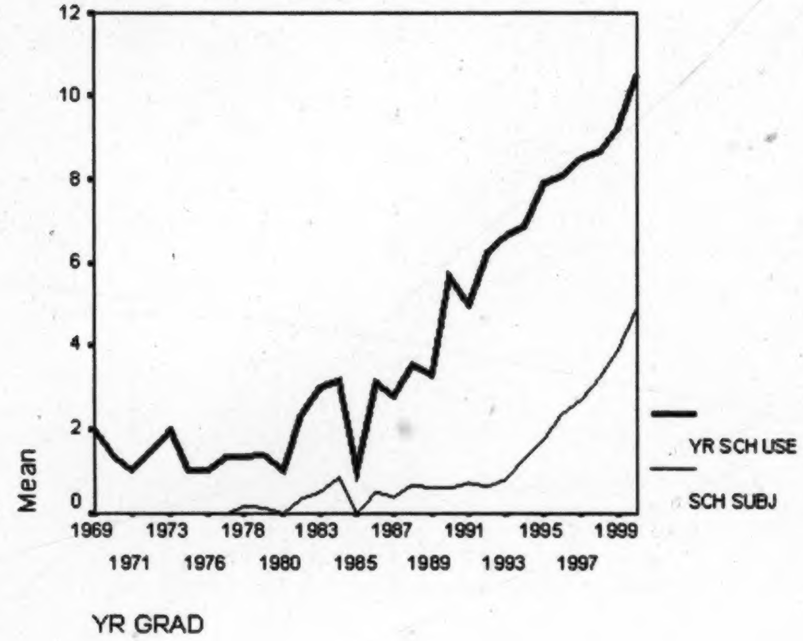
Table 14. ICT Integration by Year of High School Graduation

		SCH USE			SCH SUBJ		
		N	Mean	SD	N	Mean	SD
YR GRAD	1969	1	2.00	.	1	.00	.
	1970	6	1.33	.52	6	.00	.00
	1971	2	1.00	.00	2	.00	.00
	1972	2	1.50	.71	2	.00	.00
	1973	1	2.00	.	1	.00	.
	1975	4	1.00	.00	4	.00	.00
	1976	4	1.00	.00	4	.00	.00
	1977	3	1.33	.58	3	.00	.00
	1978	6	1.33	.82	6	.17	.41
	1979	8	1.38	.52	8	.13	.35
	1980	4	1.00	.00	4	.00	.00
	1982	3	2.33	.58	3	.33	.58
	1983	7	3.00	3.03	7	.43	.79
	1984	6	3.17	2.23	6	.83	1.17
	1985	4	1.00	.00	4	.00	.00
	1986	9	3.13	2.59	9	.44	.53
	1987	10	2.80	1.55	10	.40	.52
	1988	9	3.56	2.13	9	.67	.50
	1989	10	3.30	1.70	10	.60	.52
	1990	18	5.67	3.56	18	.61	.85
	1991	15	5.00	2.36	15	.73	.80
	1992	38	6.24	3.19	38	.61	.92
	1993	25	6.64	2.93	25	.80	.96
	1994	45	6.88	3.09	45	1.27	1.36
	1995	64	7.92	2.90	64	1.80	1.69
	1996	65	8.08	3.18	65	2.35	2.04
	1997	75	8.48	2.66	75	2.71	1.84
	1998	84	8.67	2.91	84	3.24	2.39
	1999	133	9.20	2.43	133	3.92	2.25
	2000	36	10.53	2.48	36	4.92	2.90

Table 14 provides the data related to these trends by listing the mean SCH USE and SCH SUBJ for all of the YR GRAD values reported by participants in this study and Figure 5 provides a graphical view of this same data. The number of cases per year prior to 1990 was relatively small, but those years generally had the lowest values for SCH USE and SCH SUBJ. In 1990, the mean SCH USE was 5.67 years, and the mean SCH SUBJ was .61 high school subjects. The means for the year 1995 rose to 7.92 years and

1.80 subjects and the means for the year 2000 rose again to 10.53 years and 4.92 subjects. The average increase per year from 1995 to 2000 was .522 years and .624 subjects. If we use these average increases to extrapolate to the year 2005, on average by then students should have started computer use in kindergarten (i.e., had an average of 13 years since first computer use in school) and should have had ICT integrated into 8 high school subjects.

Figure 5. ICT Integration by Year of High School Graduation



CHAPTER V: DISCUSSION

Introduction

The purpose of this study was to obtain a baseline assessment of the ICT literacy of undergraduate education students, to provide a view of the general skill level of the group as a whole, as well as determine what characteristics are associated with individual differences in ICT entry skills. Discussion will be presented related to the hypotheses made and will be based on the results of the data analysis of the previous chapter. The implications of this research on teacher education programs will also be discussed along with recommendations for further research in this area.

Assessing ICT Literacy

Hypothesis 1

The results of this study support Hypothesis 1, which stated that the average scores on both the ICT Knowledge and Performance pre-tests would be significantly lower than an assumed mastery level of 80%. In fact, the assessments obtained from the Knowledge and Performance tests used in this study indicate that, on average, student performance on these tests was well below the mastery level with means of 59.60% and 47.41% respectively. A relatively small number of the participants did achieve the mastery level on these tests - about 9% on the Knowledge pre-test, and 7% on the Performance pre-test.

These results support the conclusion that a large majority of undergraduate education students begin university studies with low levels of ICT Literacy. This study clearly does not support the belief that post-secondary students who are potential teachers are generally arriving at university with adequate computer literacy. It appears that only a small portion of students in university education studies do not require assistance with learning basic computer skills. Only a small portion are in a position to concentrate on issues related to the integration of ICT into teaching, while the remaining large majority of students appear to require assistance with learning basic computer skills as well as studying the integration of ICT into teaching.

It is, however, encouraging to note that although students' actual ICT abilities were rather low, their attitudes about the importance and usefulness of computers in education and society were fairly positive. The results of the attitude survey show that students responded very positively to statements such as "Computers help prepare students for the future," "In five years everyone will need to know how to operate a computer," and "The Internet can be a useful tool in teaching." Thus, one could argue that the students generally feel that ICT Literacy is important, but they simply haven't been exposed to computers enough at home, in K-12 school, or in post-secondary studies, to be as proficient with computers as they would like to be.

Hypothesis 2

The results of this study also support Hypothesis 2, which stated that the average scores on both the ICT Knowledge and Performance post-tests would be significantly higher than the scores on the corresponding pre-test. The post-tests indicated that after taking an educational technology course (whose major focus was learning computer technical skills), 47% of students achieved the mastery level on the Knowledge Test and 62% achieved the mastery level on the Performance Test. Although the means on the post-tests were just under the assumed mastery level (Knowledge 77.82 and Performance 79.09), it is still a concern that 53% of students did not achieve mastery on Knowledge and 38% of students did not achieve mastery on Performance. Thus, a single educational technology course proved to be helpful, increasing ICT Literacy significantly, but many of the pre-scores were so low that it appeared impossible to raise everyone to a level of mastery. Thus, one technical course currently appears to be far from a complete solution to the challenge of ensuring that all education students have adequate basic ICT knowledge and practical skills. Furthermore, this study does not touch on the subject of whether pre-service teachers can demonstrate that they are prepared to teach with technology; that is an area requiring additional research.

Predicting ICT Literacy

Hypothesis 3

The results of this study support Hypothesis 3, which stated that ICT Literacy (and Knowledge and Performance sub-scores) could be significantly predicted by some linear combination of one or more of the independent variables examined in this study.

The hierarchical multiple regression model developed in this study was able to explain 41% of the total variance in overall ICT achievement, which is a level of explanation considered very meaningful in education and other behavioral sciences (Cohen & Cohen, 1983). This study found that ICT Literacy is a complex issue and that several variables are each supplying a small "piece of the puzzle" in understanding differences in ICT Literacy. Many of the variables are individually explaining less than 10% of the variance in scores. However, in behavioral sciences, typically many variables are involved, and even these smaller levels of influence are important in understanding a complex situation (Cohen & Cohen, 1983). The sets and their component variables that were significant enough to enter the regression model (and in parentheses their levels of explanation) were: (1) Individual Characteristics – Gender (2.1%), (2) Family/SES - Home Computer (3.8%), (3) K-12 Education - High School Subjects using ICT (4.0%), (4) Academic Ability (3.1%), (5) Post-Secondary Education - Previous Credit Computer Course (4.2%) and Program Focus on Science/Math/Technology (2.7%), (6) Overall Computer Exposure - Variety of Applications Used (19.0%), and (7) Computer Attitudes - Self-Efficacy (2.0%). Thus, each of the hierarchical sets was found to be important, with at least one variable from each set entering the model.

All of the variables that entered the model were found to have a positive impact on overall ICT Literacy. The strongest predictor was Overall Computer Exposure/Variety of Applications Used. This is not surprising, as the count of the number of software applications a student has used may be thought of as a rough measure of ICT Literacy in itself. However, since the model developed presumes a set of causal priorities, all of the variables should be considered important. Individual Characteristics, Family/SES Influences, K-12 Schooling, General Academic Ability, and Post-Secondary Education may all have an impact on the amount of computer exposure a student has received, on the shaping of attitudes towards computers, and the development of ICT knowledge and practical skills.

Separate analyses on the Knowledge and Performance portions of ICT Literacy showed that Knowledge could be predicted in a similar manner to overall ICT Literacy, while for Performance, the only difference was that Academic Ability was not a significant predictor, while Year of High School Graduation was a significant predictor. Since the bivariate correlations revealed that Knowledge and Performance were highly correlated it is not surprising that the prediction models for the two types of tests were fairly similar. Since Academic Ability is normally tested in a manner more similar to the Knowledge Test than the Performance Test, it is also not surprising that this variable significantly impacted Knowledge, but not Performance. Year of High School Graduation likely entered the model for Performance because more recent graduates have had more opportunity to use computers in school than earlier (and probably older) graduates did. The following discussions regarding Hypothesis 4 and Hypothesis 5 provide additional comments on the impact of individual variables in this study.

Hypothesis 4

Hypothesis 4 stated that particular values of the categorical independent variables examined in this study would contribute positively in the prediction of pre-test ICT Literacy (and Knowledge and Performance sub-scores). The results of this study support some parts, but not all, of Hypothesis 4. Each sub-section of Hypothesis 4 is discussed separately below:

a) Male gender was shown to have a significant, positive impact on overall ICT Literacy (pre-test) as well as the Knowledge and Performance sub-scores. This supports Hypothesis 4a and is in agreement with the traditional literature on gender differences regarding computer technology. However, the effect of gender, as was the case with many of the variables examined, was not large in itself. According to the regression model for predicting pre-test ICT Literacy, gender accounted for 2.1% of the variance in overall ICT achievement, 1.4% of the variance in Knowledge scores, and 1.9% of the variance in Performance scores. Females perhaps narrowed the gender gap more on the Knowledge test due to somewhat stronger verbal skills than males (Eisenberg, Martin, & Fabes, 1996; Halpern, 2000). Thus, gender may still somewhat of an issue in computer literacy - but perhaps not as important as the traditional literature states - and slightly more with respect to practical skills than conceptual knowledge. It appears that this study provides some support for the recent literature on the narrowing of gender gaps in technology use and proficiency (Miller et al., 2001; U.S. Department of Commerce, 2000), but does not support the literature on females being more proficient with computer technology than males (Johnson & Szabo, 1998; North Carolina State, 1998).

b) Owning a home computer was also shown to have a significant, positive impact on overall ICT Literacy and Knowledge and Performance pre-scores. This supports Hypothesis 4b and the literature on concerns with respect to access to technology; that is, students without computers in their homes are at a disadvantage. Home computer ownership accounted for 3.8% of the variance in overall ICT achievement, 3.9% of the variance in Knowledge scores, and 1.9% of the variance in Performance scores. Thus, owning a home computer appears to have more of an impact on knowledge of computing concepts and terminology than on practical skills. The author's informal observations in teaching educational technology courses concur with this finding - students with a home computer do seem to have an advantage. For example, a home computer allows greater freedom and time for exploring the computer, or taking responsibility for maintaining it in good working condition, than school-based experiences alone generally permit. However, this study raises the question as to whether home computer ownership is actually an SES issue or just a personal choice issue. In this study, SES was operationalized via two variables, home computer ownership (a measure of financial means) and education of parents, and Table 11 indicates very little correlation between these two measures ($r(689) = -.022$, $p=.561$). There are several possible explanations for these results: (1) one or both of these measures of SES are invalid or unreliable; (2) these two measures each contribute something unique to the concept of SES; (3) with a restricted range the predictive power of education of parents is restricted (the average education of parents in the sample was rather high and response frequencies were heavier on the higher end of the scale, leading one to conclude that low SES individuals were largely excluded from this study); (4) financial means to purchase a home computer is only an issue at very low SES levels (i.e., most of the sample was beyond some threshold level for being able to afford a home computer); (5) at higher SES levels, home computer ownership may be influenced more by one's attitude about the importance of computers than financial means; the correlation between home computer ownership and attitude towards computers in education and society, was slightly stronger ($r(684) = .105, p<.01$) than the correlation between home computer and education of parents.

c) Access to a computer at one's workplace or another household was not a variable that had a significant enough impact to enter the regression model. However, based on the correlations (Table 11) and comparison of group means (Table 12) presented earlier, it can be argued that this variable is likely exerting some degree of influence on ICT achievement. It appears that Hypothesis 4c is partially supported, but the impact of this variable is minimal in comparison with the other variables examined. For example, home computer ownership and male gender had a larger impact than this variable and entered the regression model as indicated above. Also, access to another computer was somewhat correlated with certain variables that did enter the model (variety of applications, high school subjects using ICT, general academic ability, and computer self-efficacy) and thus was probably redundant (the regression model indicates a minimal set of variables).

d) Urban/rural had very little impact on ICT achievement, according to the results of this study, and thus Hypothesis 4d is not supported. As mentioned in the discussion on descriptive statistics, 72% of the students in this sample attended an urban high school, while 27% were attended a rural high school; thus, although urban students were in the majority, there was still a sizeable portion of the sample that came from rural areas. Urban/rural had virtually no bivariate correlation with ICT pre-scores (Table 11), there was no evidence in the comparison of group means (Table 12) that urban students had higher ICT pre-scores than rural students, and it was not significant enough to enter the regression model (Table 13). As mentioned in the literature review, urban/rural issues are related to SES issues, with rural areas possibly being at a disadvantage, particularly in terms of access to computers and the Internet. Possibly because of the generally higher SES among the students in this sample, potential disadvantages of rural living did not become evident in the results of this study.

e) Greater post-secondary experience (after-degree/fifth year or more as opposed to regular first to fourth year undergraduates) had very little impact on pre-test ICT achievement, and thus Hypothesis 4e is not supported. This variable had virtually no bivariate correlation with ICT pre-scores (Table 11), in the comparison of group means (Table 12) after-degree students did not have significantly higher ICT pre-scores than regular undergraduate students, and this variable was not significant enough to enter the regression model (Table 13). The major reason for examining this variable was the trend (observed by the author in teaching university educational technology courses) that after-degree students on average would earn higher final course grades than regular undergraduates. Based on the results of this study, it does not appear that the reason for these higher grades was significantly better pre-course ICT Literacy. There was, however, more of a positive correlation between after-degree and post-test scores. Thus, it appears that there is some support for the general observation that after-degree students take university studies more seriously; they possibly worked harder and got more out of the educational technology course, and did better on the post-test.

f) The program route variables (not elementary and not education) did not have a strong enough impact on pre-test ICT Literacy to enter the regression model. In the group mean comparisons (Table 12), there was evidence that non-elementary (secondary, adult or other education) students scored somewhat higher than elementary education students, but the difference was not statistically significant. Another reason for the not elementary variable failing to enter the regression model is that it had a strong enough correlation with other variables that did enter the model that it was deemed redundant. Two such variables were program focus on science/math/technology ($r(672) = .378$, $p<.001$) and male gender ($r(680) = .315$, $p<.001$). Students on the elementary education route are less likely to be male or to have a university program that focuses on sciences, mathematics or technology (two conditions associated with higher ICT Literacy). There was also evidence that the mean for the small group of students not pursuing an education degree was significantly higher than for the majority who claimed to be pursuing an education degree. However, the not education variable probably did not enter the regression model because correlations with other variables that entered the model (computer credit course, variety of applications, focus on science/math/technology, and computer self-efficacy) made it redundant as well.

g) University program focus (degree, major or minor) that was science, mathematics, or technology related was shown to have a significant, positive impact on pre-test ICT Literacy Composite, Knowledge and Performance. According to the regression models, this variable accounted for 2.7% of the variance in all three pre-test scores (ICT Composite, Knowledge, and Performance). Thus, students who are concentrating on sciences, mathematics and other subjects traditionally more associated with computers had somewhat higher pre-test ICT Literacy than students concentrating on humanities-related subjects such as language arts, social studies, or fine arts, which agrees with the Rosen and Weil (1995) study. Possible explanations for this are: (1) a genetic predisposition that enables one to do better in subjects such as mathematics also enables higher achievement in understanding and using computers, and (2) students in university programs focusing on science, mathematics, or technology are more exposed to computers in their post-secondary studies.

h) Previously taking a post-secondary computer-related credit course was also shown to have a significant, positive impact on pre-test ICT Literacy Composite, Knowledge and Performance scores. This supports the literature that states that individuals with more previous computer exposure will have had more time or opportunities to understand technology and proceed to higher levels of technological use (CEO Forum on Education and Technology, 1999; Mandinach & Cline, 1992; Overbaugh, 1993; Rosen & Weil, 1995). This variable accounted for 4.2% of the variance in overall ICT achievement, 4.1% of the variance in Knowledge scores, and 2.1% of the variance in Performance scores. Thus, a previous credit course on computers appears to have more of an impact on knowledge of computing concepts and terminology than on practical skills.

i) Previously taking a post-secondary computer-related non-credit course or workshop had very little impact on ICT achievement, according to the results of this study. This variable had virtually no bivariate correlation with ICT pre-scores (Table 11), there was no evidence in the comparison of group means (Table 12) that students who had taken such a course did significantly better than those who hadn't, and this variable also wasn't significant enough to enter the regression model (Table 13). It is interesting to note that a computer-related credit course has impacted ICT Literacy, while a non-credit course has not. Possible explanations for this difference are that non-credit courses or workshops are often very short and limited in scope, they may not be approached as seriously since a mark is not involved, and they may not provide as much theoretical background or practical application compared to credit courses. Perhaps it would have been more fruitful to determine *how many* non-credit courses a student had taken, rather than just ask *if* they had taken any. The Background Survey showed that relatively few students (10% of the sample) had actually taken a non-credit computer course. Perhaps this is an area that schools of education might investigate – providing more workshops on a wide range of topics and ensuring that students are more informed about such learning opportunities might have an impact on the ICT Literacy of students.

Hypothesis 5

Hypothesis 5 stated that the quantitative independent variables considered in this study would contribute positively in the prediction of ICT Literacy Composite, Knowledge and Performance pre-scores. The results of this study support some parts, but not all, of Hypothesis 5. Each sub-section of Hypothesis 5 is discussed separately below:

a) Parents' highest education had very little impact on ICT achievement, according to the results of this study. This variable had virtually no bivariate correlation with ICT pre-scores (Table 11), and it also wasn't significant enough to enter the regression model (Table 13). As mentioned in the discussion above on the home computer variable, SES was operationalized via two variables, home computer and education of parents, and there was very little correlation between these two measures. It is possible that one or both of these measures of SES are not valid or reliable or few participants had low enough SES to significantly impact ICT Literacy.

b) Years of computer use in K-12 school did not enter the regression model (Table 13), because correlations with other variables that entered the model (variety of applications, number of high school subjects that used ICT, year of graduation, and computer self-efficacy) made it redundant. In particular, years of computer use in K-12 school use was highly correlated with the number of high school subjects in which the student had used ICT (*r*(689) = .495, *p*<.001) and year of graduation (*r*(687) = .641, *p*<.001), as shown in Table 11. Years of computer use in K-12 school also had small positive bivariate correlations with ICT Composite (*r*(678) = .191, *p*<.001), Knowledge (*r*(664) = .134, *p*<.01), and Performance (*r*(592) = .209, *p*<.001) pre-scores. These findings provide some degree of support for Hypothesis 5b, that is, increased computer exposure (in this case through more years of computer use in K-12 schooling) positively impacts ICT Literacy.

c) The number of high school subjects the student took which integrated ICT had a significant, positive impact on overall ICT Literacy and Knowledge and Performance pre-scores. This variable entered the regression model and accounted for 4.0% of the variance in overall ICT achievement, 2.2% of the variance in Knowledge scores, and 4.7% of the variance in Performance scores. These findings provide support for Hypothesis 5c, that is, increased computer exposure (in this case through integration of ICT into more high school subjects) positively impacts ICT Literacy, particularly practical skills.

d) Year of high school graduation entered the regression model for the Performance pre-test (accounting for 1.5% of variance), but not for ICT Composite or Knowledge pre-scores. As shown in Table 11, year of graduation had virtually no bivariate correlation with the ICT Knowledge pre-scores (*r*(671) = .024, *p*=.527), however, it did have somewhat of a correlation with Performance (*r*(595) = .201, *p*<.001). It is also interesting to note that year of graduation was somewhat correlated with the strongest predictor, variety of software applications used (*r*(696) = .209, *p*<.001), and highly correlated with high school subjects that used ICT (*r*(696) = .503, *p*<.001) and years of K-12 computer use (*r*(687) = .641, *p*<.001). These findings provide partial support for Hypothesis 5d (i.e., with respect to Performance). Thus, students who graduated high school more recently (i.e., their year of graduation is a higher number) are more likely to have higher ICT practical skills than students who graduated longer ago.

e) General academic ability entered the regression model for ICT Composite (accounting for 3.1% of variance) and Knowledge (accounting for 4.4% of variance), but not Performance. As shown in Table 11, general academic ability had virtually no bivariate correlation with the ICT Performance pre-scores (*r*(280) = .006, *p*=.922), however it did have a small correlation with Knowledge (*r*(308) = .152, *p*<.01). These findings provide partial support for Hypothesis 5e and the traditional literature that states that academic success in college students is usually correlated with measures of previous academic ability. Since the Knowledge Test (multiple-choice) was more similar to traditional methods of assessing academic achievement than the Performance Test, it is not surprising that general academic ability emerged as a significant predictor for Knowledge, but not Performance. However, these results contradict the literature that states that general academic ability is usually the strongest predictor of achievement in college students. In this study, general academic ability was the second strongest predictor of ICT Knowledge, the fifth strongest predictor of ICT Composite, and not a significant predictor at all of ICT Performance. Thus, it appears the ICT Literacy is a much different issue than competence in traditional areas tested in college. As discussed in the literature review, computers have become a tool that virtually any individual can use; they are not just for scientists, programmers, or the academically gifted. ICT student standards (Alberta Learning, 2000; ISTE, 1998) state that virtually all students should be able to achieve a certain level of ICT Literacy, regardless of academic ability.

f) Years of overall computer use did not enter the regression model (Table 13) because correlations with stronger variables that entered the model (credit course, variety of applications, and computer self-efficacy) made it redundant. Years of use had small positive bivariate correlations with ICT Composite (*r*(680) = . 249, *p*<.001), Knowledge (*r*(666) = . 230, *p*<.001), and Performance (*r*(596) = .194, *p*<.001) pre-scores. These findings provide some degree of support for Hypothesis 5f, that is, increased computer exposure through more years of general computer use may positively impact ICT Literacy.

g) The variety (count) of software applications used was shown to have a significant, positive impact on overall ICT Literacy (pre-test) as well as the Knowledge and Performance sub-scores. According to the regression model for predicting pre-test ICT Literacy, the variety of applications was the strongest predictor of pre-test ICT Literacy - it accounted for 19.0% of the variance in overall ICT achievement, 15.0% of the variance in Knowledge scores, and 17.8% of the variance in Performance scores. These findings strongly support Hypothesis 5g, that is, increased computer exposure (in this case through experience with a larger number of software applications) positively impacts ICT Literacy. Informal observations in the undergraduate educational technology classes at this institution concur with this finding. Students who enter these courses with relatively limited previous computer experience often find the courses extremely challenging. According to this study, it also appears that the use of computer applications involves both cognitive/verbal and procedural components, since both knowledge and practical skills were strongly impacted.

h) Personal feelings of self-efficacy concerning the use of computers had a significant, positive impact on overall ICT Literacy and Knowledge and Performance pre-scores. This variable entered the regression model for all three variables. It accounted for 2.0% of the variance in overall ICT achievement, 1.7% of the variance in Knowledge scores, and 1.6% of the variance in Performance scores. These findings provide support for Hypothesis 5h and the corresponding literature, that is, individuals with higher computer self-efficacy will have higher computer proficiency. The unique contribution of this variable was not as high as most of the other variables that entered the regression model, although self-efficacy had relatively high bivariate correlations with ICT Composite (*r*(677) = . 532, *p*<.001), Knowledge (*r*(672) = .482, *p*<.001) and

Performance ($r(588) = .476$, $p<.001$) pre-scores. The most reasonable explanation for this is that self-efficacy is largely redundant with (in fact likely caused by) many of the other variables that did enter the regression model. The frequencies for the self-efficacy gain scores indicate that the vast majority (81.2 %) of students increased their self-efficacy after taking an educational technology course that focused on learning new software applications. An examination of the bivariate correlation between self-efficacy and other variables also supports this idea: home computer ($r(684) = .262$, $p<.001$), credit course ($r(682) = .182$, $p<.001$), program focus on technology ($r(669) = .152$, $p<.001$), male gender ($r(677) = .135$, $p<.001$), variety of applications ($r(684) = .701$, $p<.001$), high school subjects that used ICT ($r(684) = .260$, $p<.001$), and year of graduation ($r(680) = .106$, $p<.001$). The accumulated influences of all of the significant variables that entered the model in the previous sets (Individual Characteristics, Family/Community/SES influences, K-12 Education, Academic Ability, and Post-Secondary Education) probably had an impact on computer self-efficacy. However, there was still a large enough component of self-efficacy that was not redundant with the other variables that allowed the self-efficacy to be significant enough to enter the regression model.

i) Personal attitudes toward computers in society/education had very little impact on ICT achievement, according to the results of this study. This variable had only small correlations with ICT pre-scores (Table 11), and it also wasn't significant enough to enter the regression model (Table 13). As mentioned in the section on Attitude Survey descriptives, typically students had higher scores on the part of the survey pertaining to this variable than on the self-efficacy part. Thus, this study found that, in general, the students felt that computer technology is important in society and education, but they personally did not have as positive feelings about their own ability to use computers. Self-efficacy, and all of the related variables that appear to affect self-efficacy, were stronger predictors of ICT Literacy than general attitudes about computers.

ICT Trends in K-12 Schools

Hypothesis 6

Hypothesis 6 stated that recent high school graduates started ICT use in school in earlier grades than those who graduated longer ago. Since the sample in this study included students with a wide range of graduation years, it was possible to obtain data to test whether this trend exists, and the results clearly support this hypothesis; in general students are now starting to use computers in school much earlier than they did in the past. This provides concrete evidence that what many may have informally assumed has been occurring in schools is indeed occurring. For example, a 1990 high school graduate in this geographic area likely started using computers in grade 7, a 1995 graduate in grade 5, and a 2000 graduate in grade 2. Shortly, the norm will likely be that students will have used computers throughout their entire K-12 schooling, assuming the trend is linear.

Hypothesis 7

Hypothesis 7 stated that recent high school graduates had ICT integrated into more high school courses than those who graduated longer ago. As with Hypothesis 6, since the sample in this study included students with a wide range of graduation years, it was possible to obtain data to test whether this trend exists, and the results clearly support this hypothesis; in general students are now using ICT in more high school subjects than they did in the past. This provides additional concrete evidence that the increased integration of ICT that many may have informally assumed has been occurring in schools in this geographic area is indeed occurring. For example, a 1990 high school graduate likely used computers in only 1 high school subject area, a 1995 graduate in 2 subjects, and a 2000 graduate in 5 subjects. Within a few years, the norm will likely be that students will have used computers in the vast majority of their high school subject areas, assuming the trend is linear.

Impact of Trends in K-12 Schools on ICT Literacy

The results related to Hypotheses 6 and 7 provide strong evidence that ICT application in K-12 schools has markedly increased in recent years in the geographic area covered by this study. Students who graduated from high school more recently generally reported having first used computers earlier in their K-12 schooling and having been required to use computers in more high school subjects. An extrapolation revealed that by the year 2005 students should have on average started computer use in kindergarten and had ICT integrated into 8 high school subject areas.

This study found that this increased exposure to ICT in K-12 schooling had a significant, positive impact on ICT Literacy. In particular, it was found that individuals who had experienced a greater number of high school subjects that integrated ICT generally had higher Knowledge, Performance and overall ICT Literacy scores. It was also found that more recent high school graduates scored higher on the ICT Performance Test (practical skills) than earlier graduates.

Another variable that was examined regarding influences in K-12 education was the overall years of computer use in K-12 school. This variable did not enter the regression model, but correlations indicated that this was likely due to redundancy with other variables. For example, it was highly correlated with the variables discussed in the preceding paragraph: high school subjects using ICT ($r(689) = .495, p<.001$) and year of graduation ($r(687) = .641, p<.001$). Years of K-12 computer use also had small positive bivariate correlations with ICT Composite ($r(678) = .191, p<.001$), Knowledge ($r(664) = .134, p<.01$), and Performance ($r(592) = .209, p<.001$) pre-scores.

Thus, integrating ICT into a larger number of school subjects and generally starting ICT exposure earlier appear to have a positive impact on ICT Literacy, and this is increasingly evident in more recent graduates. Thus, one would expect that if ICT use in K-12 schools continues to increase, the ICT Literacy level of students entering post-secondary studies (in particular those entering teacher preparation programs) will continue to rise. K-12 schooling must be expected to provide a significant portion of a student's exposure to ICT, and the current situation (as per the baseline assessment) is that students overall do not appear to have enough exposure to ICT in their K-12 education. However, if the apparent trends discussed above are real, this situation should ameliorate with each passing year.

K-12 programs should also be aware of the characteristics associated with individual differences in ICT Literacy that have been identified in this study or in the literature. K-12 schools should continue to take measures to ensure that both boys and girls, both humanities and science-oriented students, and all students regardless of academic ability or family SES (especially access to a home computer), have ample opportunity for ICT experience. K-12 schools also have an important role to play in fostering positive attitudes and self-efficacy regarding the use of computers.

Implications for Teacher Education Programs

This study indicates that basic computer literacy in undergraduate students is still a major issue that schools of education must address. Pre-service teacher education programs cannot yet assume that entering students have generally had adequate ICT exposure in high school, in other previous studies, or at home. The results of the baseline assessment indicated that education student computer literacy levels are generally low and thus there is a strong need for increasing the knowledge and skills of students in this area. This could be done either by establishing a minimum level of ICT Literacy as an entrance requirement to the faculty or by providing computer productivity tools instruction of some form within education undergraduate programs. Such instruction could be accomplished by ICT specific courses, by incorporating ICT into other aspects of teacher preparation programs, or some combination thereof.

The present data show that taking one ICT-specific course improves the ICT Literacy level of students to the point where about half or more of students are at a mastery level in ICT knowledge and practical skills. This is commendable to a point, but this alone is not enough to claim that education graduates are ICT literate. Furthermore, a single educational technology course which focuses mainly on computer technical knowledge could not be presumed to have a great impact on pre-service teachers' ability to integrate technology into teaching. Either additional ICT-specific courses would be required or ICT must be included in methods courses, practicum experiences, or other aspects of teacher preparation programs. There is much support in the literature for the viewpoint that integration throughout the program is ultimately a better philosophy than simply providing separate computer courses (Bielefeldt, 2001; Brush et al., 2001; Milken Exchange on Educational Technology, 1999a; President's Committee of Advisors on Science and Technology, 1997; U.S. Congress - Office of Technology Assessment, 1995). However, this study indicates that, given the present level of ICT Literacy in education undergraduates, it would not be wise to teach courses on the application of ICT to teaching without including some instruction aimed at increasing students basic ICT technical competence.

Based on the results of this study, a general recommendation for schools of education would be to initially do the much simpler task of providing a separate ICT course for education undergraduates, which as a minimum addresses the area of basic computer technical skills, then proceed with the more difficult task of increasing the level of ICT integration (including technical instruction, if necessary) within methods course, field experiences and other areas of undergraduate education programs. Eventually the ICT-technical course could be phased-out when the rest of the program is sufficiently covering the development of ICT skills (or, when at some point in the future, the vast majority of students enter the program with adequate ICT technical competency).

Recommendations for Further Research

Based on the literature and the results of this study, the following are recommendations for further research in this area:

1. This study should be repeated in this same environment to validate the results.
2. A longitudinal study on education students should be undertaken to enable comparisons of the ICT Literacy level of the sample covered by this study with those in subsequent years to determine whether there is a trend towards increased ICT Literacy when pre-service teachers begin post-secondary studies.
3. The instruments developed in this study should be used in other environments to test their validity and reliability in other situations.
4. The content of the ICT Knowledge and Performance instruments could be expanded to provide a more comprehensive ICT Literacy test. In particular, the Performance Test could be modified to test skills regarding additional software applications or

operating system features.

5. This study should be repeated in other environments (universities, colleges, etc.) to see whether similar or different results arise. For example, other faculties and other schools of education may find this study of interest and may wish to compare their own situations in this area with the use of the instruments developed (or adaptations). In particular, colleges that cooperate with this university via B.Ed. transfer programs may wish to repeat this study on their education undergraduates.
6. This study should be replicated on other groups of post-secondary students to enable comparisons of the ICT Literacy level of education students with those in other types of studies.
7. The ICT Literacy tests developed in this study should be adapted for use at other points in education studies. Examples are:
    - As a test of mastery at the exit point of bachelor of education programs
    - Portions of the test could be used at multiple points if smaller sets of ICT skills are taught in a variety of education courses
    - The tests could be expanded and adapted for the purpose of individualizing computer technical skills instruction as part of a computer managed instructional system
8. The instruments developed in this study should be adapted for use in K-12 school environments for the purpose of longitudinal studies that would assess the ICT Literacy of students and determine if there is a trend towards increasing ICT use and ICT literacy in the geographic area covered by this study, in other regions in Canada and in other countries. Such K-12 studies may also be able to identify additional variables regarding ICT use in schools that will provide greater understanding of individual differences in ICT Literacy. This study only examined two simple variables related to the earliest grade of computer use and a count of the number of high school subjects that used computers. There are likely a host of other school-related variables that may increase our understanding of K-12 ICT Literacy such as school SES, school type, attitude of principal and other teachers regarding technology, expenditures on technology (e.g., hardware, software, and support), professional development

opportunities, teacher ICT Literacy, student-computer ratio, level of Internet access, amount of time students have access to computers, level of sophistication in the use of particular software tools, and the complexity of projects completed using technology.

9. Research should be undertaken to further investigate the area of computer self-efficacy to determine what factors affect self-efficacy, to what extent self-efficacy influences motivation to explore computers, and to what degree ICT Literacy is impacted.
10. Additional research should be conducted into the area of gender differences in ICT Knowledge and Performance. This research should include qualitative studies to investigate various aspects of ICT gender differences in detail. In addition, a literature review should be conducted to test the hypothesis that gender differences regarding ICT have been narrowing with time.
11. Another suggested area of investigation is to examine general academic ability as a predictor of declarative knowledge, but not of procedural knowledge (performance or practical skills), and attempt to identify reasons for this difference.
12. Further research should be conducted into developing and implementing models for covering ICT in teacher education programs. Teacher education programs must help pre-service teachers increase their level of ICT knowledge and practical skills along with their understanding of integrating ICT into teaching. Coursework is only one aspect of incorporating ICT into education programs. Through leadership and long-range planning, schools of education must develop broader approaches that also consider facilities, technical support, professional development, faculty incentives, and field experiences (Bielefeldt, 2001).

Conclusion

This study found that a large majority of undergraduate education students have low levels of ICT Literacy, and thus there is a strong need for increasing the ICT Literacy of these students. Amount and variety of previous computer experience are important influences on a student's level of ICT Literacy and are positively impacted by previous technology use in both K-12 and post-secondary education, as well as access to ICT in the home. General academic ability, gender (favoring males) and attitudes of computer self-efficacy are additional predictors of ICT Literacy. Taking a post-secondary educational technology course that concentrates on development of technical competencies also appears to have a strong, positive impact on pre-service teachers' ICT Literacy.

This study also provided evidence that ICT application in K-12 schools has markedly increased in recent years. If this trend continues, the ICT Literacy level of students entering post-secondary studies, in particular those entering teacher preparation programs, should continue to rise. Perhaps within a few years, development of basic ICT skills and knowledge in education students may not be such an issue, as the majority of students may possess those skills prior to beginning post-secondary studies. Teacher education programs could then focus more resources on improving pre-services teachers' abilities to integrate technology into their teaching.

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APPENDIX A:
Course Outlines

Course Outline 1 (recommended computing option)

The course objectives are taken directly from the ICT (Information and Communication Technology) program of studies published by the provincial ministry of education. This document describes the technology skills that students should master by the end of grades 3, 6, 9 and 12. This course will largely address elements in the "Processes for Productivity" section of these outcomes; i.e. those objectives concerned with the learning of software tools. Although this course is primarily a software tools literacy course, it will also attempt to provide the students with some exposure to curriculum integration. Module assignments will be curriculum-relevant projects such as excerpts from the ICT illustrative examples. Below is a listing of the 5 modules students are required to complete:

1. Internet Tools (Web browsing/searching/conferencing, FTP, Telnet, Email, Web page creation)
2. Digital Media Processing (drawing/painting, scanning, digital photography, digital audio/video, file compression)
3. Multimedia Presentation: (Microsoft PowerPoint or HyperStudio)
4. Spreadsheet (e.g. Excel)
5. Database (FileMaker Pro or Microsoft Access)

Prerequisites

- Basic computer operation (power on/off, handling floppy disks, etc.)
- A computer Operating System (OS) which employs a Graphical User Interface (GUI), either MacOS or Microsoft Windows
- Creating, manipulating, and managing files and directories (folders)
- Basic word processing (e.g. Microsoft Word, Word Perfect, or ClarisWorks)
- Basic Internet skills (email and web browsing)

If you are deficient in basic computer skills or word processing, pre-session study is strongly recommended. You should go through the optional remedial modules: Module A: Personal Computers (Introduction), and Module B: Word Processing (Introduction). In addition, you should preview Module 1: Internet Tools and obtain some assistance in using the Internet for email and web browsing.

Important: Remedial modules do not count toward your final grade.

Evaluation

Assignments: 30%
For each of the 5 required modules (Internet Tools, Digital Media Processing, Multimedia Presentation, Spreadsheet, and Database) students must submit one or more

related assignments. The total weight of all of the assignments is 30% of the overall course grade.

Exams: 70%
There will be two computer-based exams in this course: (1) a midterm exam worth 30% of the overall grade, and (2) a final exam worth 40%. The exams will be completely open book (notes, manuals, and access to the course website will be allowed). Each exam will require students to demonstrate familiarity with computer terminology / concepts and to create a number of small projects or computer files using the software tools taught in this course.

Course Outline 2

With the rapid advance in software and hardware technology, the field of Educational Technology and Educational Media has undergone tremendous changes over the past few years. Although it is still important to understand how technology can be used to assist in the development and presentation of instructional material, one can also think about how students in grades K-12 can use technology themselves to construct a learning environment.

Evaluation

Students will submit 6 module portfolios of project work (65% of final grade) and do a practical lab exam (35% of final grade):

Portfolio 1 - Internet Assignments (BookMarks, Email, FTP, ListServer)
Portfolio 2 - Multimedia Clip Samples (Images, Audio, Video)
Portfolio 3 - Spreadsheets/ Database/ Charts
Portfolio 4 - On-Line Multimedia Presentation (PowerPoint)
Portfolio 5 - Hypermedia Application (HyperStudio)
Portfolio 6 - Web Site Development

The portfolios will be based on a common content theme. Students will select a topic area like volcanoes (K-12 topic) and use this for all assignments. Students will collect both digital and analog material related to their selected topic area. The analog information can be gathered in the traditional way, i.e., library or personal material. The digital information can also be obtained from the library or from a personal collection but emphasis will be placed on gathering such information from the Internet.

Lab Exam:
Students will be required to complete, within a 2 hour period, a number of small projects using the tools they have learned in this course.

APPENDIX B:
ICT Literacy Research Consent Form

Research Project Overview

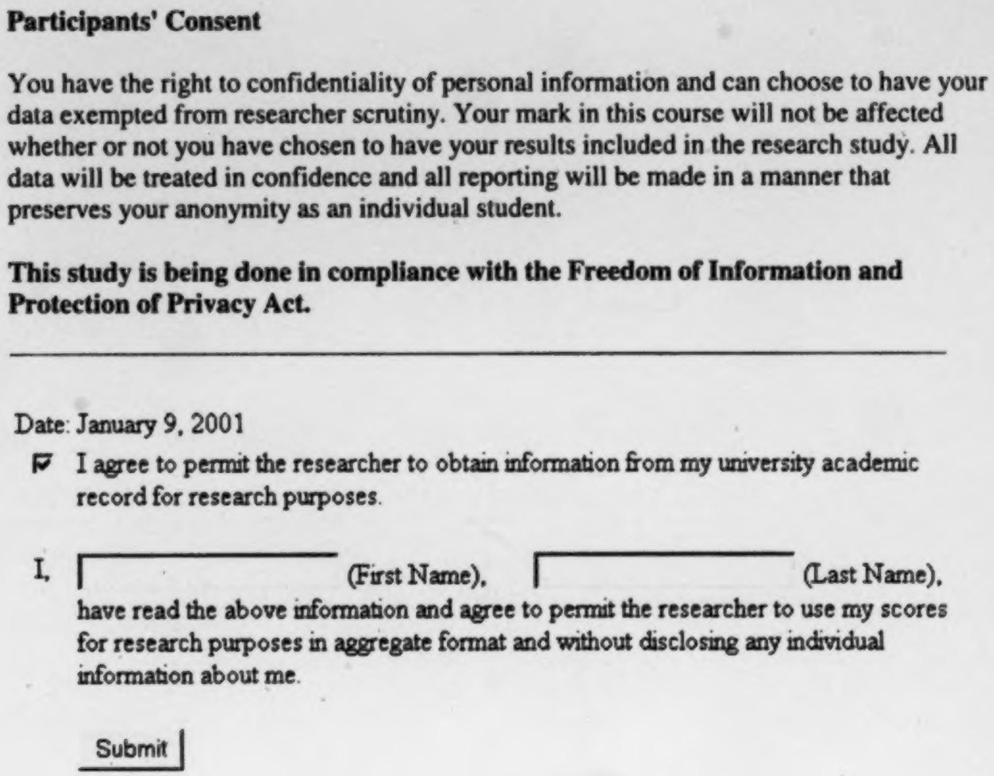
In this research project, I am examining the relationship between Information and Communication Technology (ICT) expertise and other characteristics of undergraduate education students. I am developing an online assessment tool which will provide a profile of student knowledge of basic ICT areas. Hopefully this assessment may help you and your instructor tailor this course to best suit your needs. This study will also provide information to the Faculty of Education which may lead to improvements in educational computing courses and ultimately in the integration of technology in various aspects of the B.Ed. program.

We are asking you to spend approximately 90 minutes in your first computer lab class to complete some forms and tests. First you must carefully read and fill in the bottom of this consent form.

Upon submission of this consent form, you will:

1. Complete a web-based "Student Background Survey" which asks multiple-choice or short-answer questions concerning demographics, previous experiences and current university program.
2. Complete a web-based "Computer Attitudes Survey" which asks multiple-choice questions concerning your confidence or attitudes about computers.
3. Take a web-based "ICT Knowledge Test" which contains multiple-choice questions on computer terminology, word processing, the Internet, digital media, spreadsheets, and databases. These topics are part of the provincial K-12 technology outcomes.
4. Take an "ICT Practical Test", which consists of a few hands-on computer tasks related to basic computer use, file management, word processing, and use of a spreadsheet program.

Later in the term, further information on student ICT expertise will be gathered by reviewing completed course assignments or exams. Some students may also be invited to participate in a personal interview (approximately 15 minutes). In addition, information on previous academic achievement will be obtained from student records. All data will be coded to remove individual identity and will be kept in a secure location.



Participants' Consent

You have the right to confidentiality of personal information and can choose to have your data exempted from researcher scrutiny. Your mark in this course will not be affected whether or not you have chosen to have your results included in the research study. All data will be treated in confidence and all reporting will be made in a manner that preserves your anonymity as an individual student.

This study is being done in compliance with the Freedom of Information and Protection of Privacy Act.

Date: January 9, 2001

☑ I agree to permit the researcher to obtain information from my university academic record for research purposes.

I, ______ (First Name), ______ (Last Name), have read the above information and agree to permit the researcher to use my scores for research purposes in aggregate format and without disclosing any individual information about me.

APPENDIX C:
Proposal to Access Student Records

General description of research project

The project is entitled: Assessing and Predicting Information and Communication Technology Literacy in Education Undergraduates and is being undertaken as the researcher's doctoral thesis in Educational Psychology / Instructional Technology. The objectives of this study are: (1) to develop a computerized system which assesses an individual's Information and Communication Technology (ICT) knowledge and skills and provides a profile for each participant; (2) to gather information on the personal characteristics and ICT literacy of undergraduate education students; (3) to determine whether there are characteristics (such as previous academic performance, gender, attitude, or previous computer experience) associated with students with greater ICT expertise. Data analysis techniques such as correlation and multiple linear regression will be used to determine which characteristics best predict ICT Literacy. Participants will be drawn from students registered in approved B. Ed. computing option courses. Data will be gathered in the Fall 2000 and Winter 2001 terms (estimated n = 800). Students will be tested both at the beginning of their course (pre-test) and near the end (post-test). Participation will be entirely voluntary and will require filling in a consent form (see attached sample). Participants will be assessed via computer during scheduled course lab sessions held in a campus computer lab facility.

Rationale for access to personal information

This project requires access to information concerning the previous academic performance of participants (past University GPA or high school marks). This information is important to the study because past research has shown that post-secondary achievement is highly related to prior academic achievement, such as high school grades or college entrance examinations. This study will test whether or not this normally powerful predictor is as strong in the case of computer expertise. Since there is a wide range in the degree to which technology is integrated in K-12 schools and many students may have obtained computer experience outside of school, it seems possible that this factor may not be as important as it is in predicting achievement in traditional college courses. This study seeks to identify which factor(s) are most strongly correlated with performance on ICT knowledge and skill tests; the study would be incomplete if previous academic performance is not considered as a possible predictor.

How the personal information will be used

Several pieces of data will be gathered concerning each participant. First, a number of items which are plausible predictors of ICT expertise will be obtained including: amount of previous school and non-school computer use, gender, type of university program, socio-economic status, and attitude / self-efficacy regarding computers. Second, ICT expertise will be measured via two different tests a) Abstract Knowledge - a multiple-choice test concerning ICT terminology and general concepts, and b) Performance - an authentic assessment of computer practical skills as measured by a set of hands-on computer tasks that students must complete. These items will all be gathered via computer and stored in a electronic database which identifies each participant using their University Computing ID. It is hoped that the information requested from university records (prior academic scores) can be a component of the set of predictor variables which will be compared with the two dependent measures to determine which variables most strongly predict ICT expertise.

Period of time of use of records

The requested data will be used during the 2000/2001 academic year. The researcher-gathered data will be obtained during the Fall 2000 (September - December 2000) and Winter 2001 (January - April 2001) terms. This will be followed by a period of final data analysis (April - June 2001). It is hoped that the requested records could be made available to the researcher by April 1, 2001.

Benefits of the research

The assessment system will provide relevant information to the participants which could enable student self-direction, individualization within courses, or improved program planning. The Faculty of Education may use the data to guide future decisions regarding ICT in B.Ed. programs. This study will specifically result in data useful in reassessing the need and strategies for delivering computer productivity tools instruction, which are important considerations in the design of either ICT-specific courses or other education courses which incorporate ICT. The instruments and baseline data resulting from this study will enable future comparisons with the same students or different students. Other faculties or institutions may also find this study of interest and may wish to compare their own situations in this area with the use of the instruments developed (or adaptations). By enabling early identification of ICT weaknesses and factors associated with ICT expertise in post-secondary students, this research should also provide interesting information to those involved in delivering K-12 school programs or evaluating student achievement of the provincial K-12 technology standards.

Data security and confidentiality

The data collected in this study will be stored in a database on a secure computer located in the researcher's campus office. Only the researcher and thesis supervisor will have access to this database - an ID and password are required to logon to the computer and view the database. Once the requested data from university records has been combined with the researcher-gathered data (individual records identified by Student ID), a final set of data with individual identifiers removed will be produced. This should occur by April 30, 2001. Instead of Student ID, individual records would then be labeled with a meaningless record number which in no way could be used to trace information back to any particular individual. The final statistical analyses for this project will be done using only the set of data stripped of individual identifiers. Any reports resulting from this research will be completed in a manner that preserves the anonymity of each individual student. The students are assured on the consent form (filled in prior to participating) that results will only be published in aggregate format; i.e. no information concerning individual participants will be disclosed.

Telecommunications security

It is not yet determined by what means the data from university records will be received, although some form of computer file is preferred so that less time will be required to add it to the database mentioned above. Probably the most secure method of receiving this data would be for the appropriate authority to store it on a computer disk which would be handed over in person to the researcher. Alternatively the data could be sent via email or Internet FTP (File Transfer Protocol) in an encrypted or password-protected format.

Records Requested

The researcher will provide the university with a computer file containing a list of the Student ID's of all students who have filled in a consent form indicating their voluntary participation in this study, including giving the researcher permission to access their previous academic record. These consent forms will be gathered in September 2000 and January 2001 from students registered in Educational computing courses. What the researcher would like the university to provide is a similar computer file with a previous academic average noted beside each Student ID and some indication as to what the score represents and what scale it is based on. Some discussion with personnel responsible for student grades may be required in order to identify exactly what data is will be practical to obtain in electronic format.

The researcher is concerned about obtaining scores which can ultimately be converted to a common scale, so that the scores can be correlated with the other data in the study. If certain students attended this university in previous year(s), then a cumulative GPA on the 9-point scale should be available. However, if a student's previous post-secondary work was at a different institution the available data might be a grade based on a different scale, such as a letter or 4-point grade. Another situation arises if a student is just starting post-secondary studies in which case their previous academic score would be their high school graduation grades, which in this province are percentages. Ideally the university will provide the researcher with scores which are all converted to a single scale. If this is not possible, the university should provide the researcher with information on how to convert the data from one grading scale to another.

APPENDIX D:
ICT Literacy - Student Background Survey

Please answer all of the questions on your own and to the best of your ability. When you have completed the survey, click your mouse on the **Submit Answers** button at the bottom of the form.

---

1. **Do you have a home computer?**

   ○ Yes ○ No

If you answered Yes to the above question, please answer Questions 2 to 5. If you answered No, please skip to Question 6.

2. **What type of home computer do you have? Check ALL applicable items.**

   ☐ Unsure ☐ Windows ☐ Macintosh ☐ Other type

3. **What is the maximum speed of your home computer CPU?**

   ○ Not sure ○ Less than 100 MHz ○ 100 - 199 MHz ○ 200 - 299 MHz
   ○ 300 - 399 MHz ○ 400 - 499 MHz ○ 500 MHz or more

4. **What is the approximate speed of your home Internet connection?**

   ○ Not sure ○ No Internet connection ○ Slower than 56K ○ 56K ○ 64K
   ○ 128K ○ Cable Modem ○ ADSL ○ Other Fast Connection

5. **Which of the following hardware components are included in your home computer system? Check ALL applicable items.**

   ☐ None
   ☐ Printer-black & white only
   ☐ Printer-colour capable
   ☐ Scanner
   ☐ Digital camera
   ☐ Video digitizing card
   ☐ Joystick
   ☐ Speakers
   ☐ Microphone
   ☐ Modem
   ☐ LAN (Local Area Network)
   ☐ CD-ROM drive
   ☐ Large hard drive (> 10 GigaBytes)
   ☐ Zip, Jaz, or equivalent disk drive
   ☐ CD writer
   ☐ Tape backup

Please continue on to Question 6 now.

6. **Do you have frequent access to a computer at your workplace or at another household?**

   ○ Yes ○ No

7. **In what year did you FIRST use a computer? (Enter a 4-digit number)**

8. **Which of the computer applications below have you used? Check ALL applicable items.**

☐ None
☐ Word Processing
☐ CD-ROM Reference Material
☐ Desktop Publishing
☐ Electronic Presentation
☐ Spreadsheet
☐ Database
☐ Computer Programming Language
☐ Games
☐ Email (Electronic Mail)
☐ World Wide Web Browser
☐ Telnet
☐ FTP (File Transfer Protocol)
☐ Online Conferencing
☐ Webpage Editor
☐ Accounting/Tax Software
☐ Draw/Paint
☐ Scanning
☐ Digital Camera
☐ Digital Audio Editing
☐ Digital Video Editing
☐ Graphic Animation
☐ File Compression
☐ CAD (Computer-Aided Design)

---

9. **Which of the software below have you used? Check ALL applicable items.**

☐ None
☐ AppleWorks/ClarisWorks
☐ Claris Home Page
☐ FileMaker Pro
☐ QuickTime Player
☐ HyperStudio
☐ Lotus 1-2-3
☐ WordPerfect
☐ Corel Draw
☐ Quattro Pro
☐ Paradox
☐ Corel Gallery
☐ Color It!
☐ GIFConverter
☐ GIFBuilder
☐ Netscape
☐ WinZip
☐ Aladdin/Stuffit Expander
☐ Eudora
☐ NCSA Telnet
☐ WinQVT
☐ Fetch
☐ WS_FTP
☐ Adobe Acrobat Reader
☐ Adobe PhotoShop
☐ Adobe Illustrator
☐ Adobe Premiere
☐ Adobe PageMill
☐ GraphicConverter
☐ GIF Construction Set
☐ Microsoft Works
☐ Microsoft Word
☐ Microsoft PowerPoint
☐ Microsoft Excel
☐ Microsoft Internet Explorer
☐ Microsoft Outlook
☐ Microsoft Access
☐ Microsoft FrontPage
☐ Microsoft PhotoDraw
☐ Microsoft Image Composer
☐ Microsoft GIF Animator
☐ PaintShopPro
☐ Graphic Workshop Pro
☐ LView Pro

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10. **Which of the operating systems below have you used? Check ALL applicable items.**

☐ None
☐ Microsoft Windows 3.x / 95 / 98 / 2000
☐ Microsoft Windows NT
☐ MS-DOS
☐ IBM OS/2
☐ Macintosh
☐ Unix

11. **In what grade did you FIRST use computers in SCHOOL?**

Click here to select a response ▾

---

12. **In which of the following senior high school subjects were you required to use computers at some time?**

- ☐ None
- ☐ Mathematics
- ☐ Chemistry
- ☐ Physics
- ☐ Biology
- ☐ Computing Science
- ☐ Other Science course
- ☐ Art
- ☐ Music
- ☐ Drama
- ☐ Social Studies
- ☐ English Language Arts
- ☐ French Language Arts
- ☐ Other Humanities course
- ☐ Physical Education
- ☐ Health
- ☐ Industrial Arts
- ☐ Home Economics
- ☐ Other Career & Technology Studies course
- ☐ Any other course

---

13. **In what year did you graduate from senior high school? (Enter a 4-digit number)**

---

14. **Where were you living during your final year of senior high school?**

- ○ University metro area (within 25 km of City 1)
- ○ City 2 metro area (within 25 km of City 2)
- ○ Other urban area in province
- ○ Rural area in province
- ○ Urban area outside of province
- ○ Rural area outside of province

---

15. **What is the highest level of schooling completed by either of your parents?**

- ○ less than grade 7
- ○ less than grade 10
- ○ some senior high school
- ○ senior high school diploma
- ○ less than 4 years post-secondary
- ○ 4-year undergraduate degree
- ○ some graduate school
- ○ Masters degree
- ○ Doctoral degree

---

16. **Have you previously completed a post-secondary (for credit) course whose principal topic was related to computer technology?**

○ Yes ○ No

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17. **Since you began post-secondary studies, have you taken any non-credit course, seminar or workshop whose principal topic was related to computer technology?**

○ Yes ○ No

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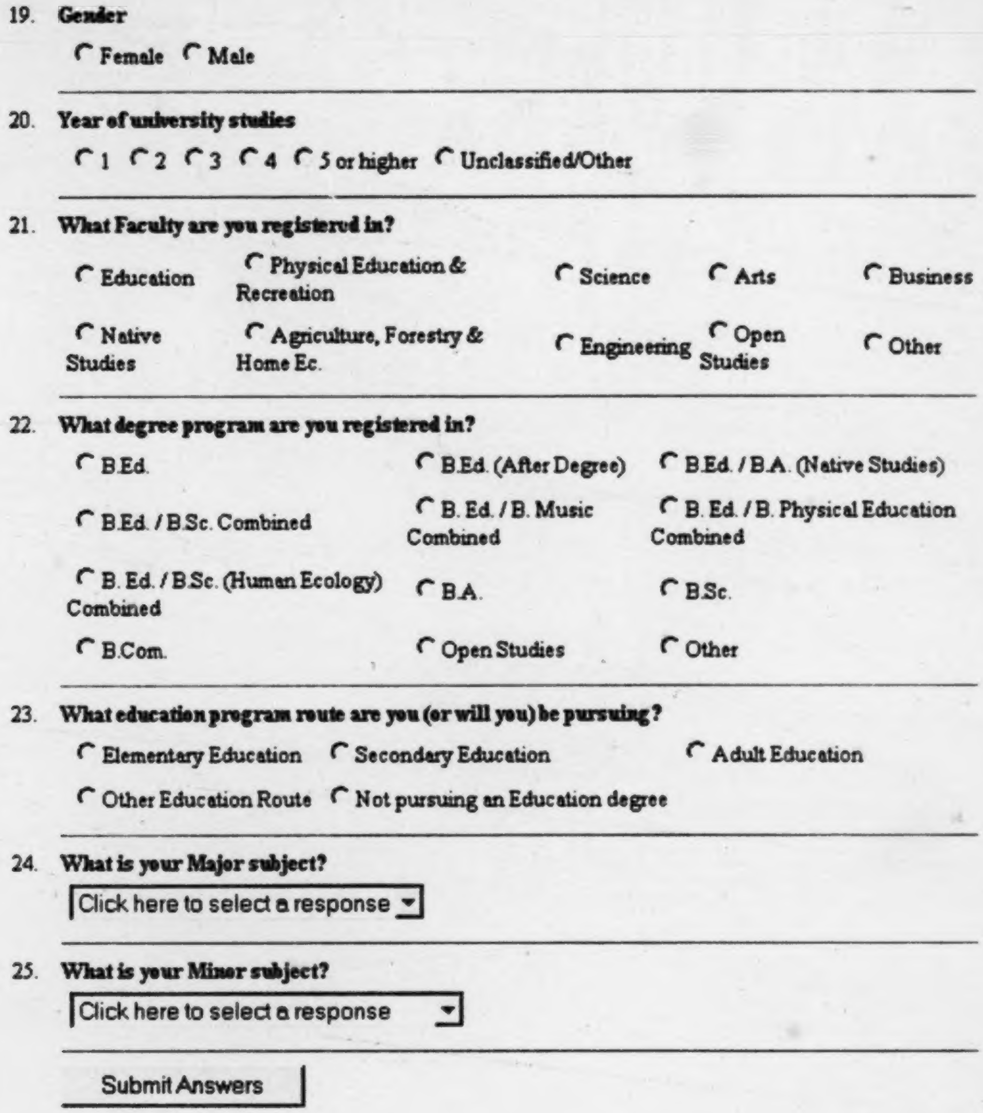
18. **What computing course are you CURRENTLY registered in?**

○ Course 1 ○ Course 2 ○ Course 3 ○ Course 4 ○ other ○ none



19. **Gender**

○ Female ○ Male

---

20. **Year of university studies**

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 or higher ○ Unclassified/Other

---

21. **What Faculty are you registered in?**

○ Education	○ Physical Education & Recreation	○ Science	○ Arts	○ Business
○ Native Studies	○ Agriculture, Forestry & Home Ec.	○ Engineering	○ Open Studies	○ Other

---

22. **What degree program are you registered in?**

○ B.Ed.	○ B.Ed. (After Degree)	○ B.Ed. / B.A. (Native Studies)
○ B.Ed. / B.Sc. Combined	○ B. Ed. / B. Music Combined	○ B. Ed. / B. Physical Education Combined
○ B. Ed. / B.Sc. (Human Ecology) Combined	○ B.A.	○ B.Sc.
○ B.Com.	○ Open Studies	○ Other

---

23. **What education program route are you (or will you) be pursuing?**

○ Elementary Education ○ Secondary Education ○ Adult Education

○ Other Education Route ○ Not pursuing an Education degree

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24. **What is your Major subject?**

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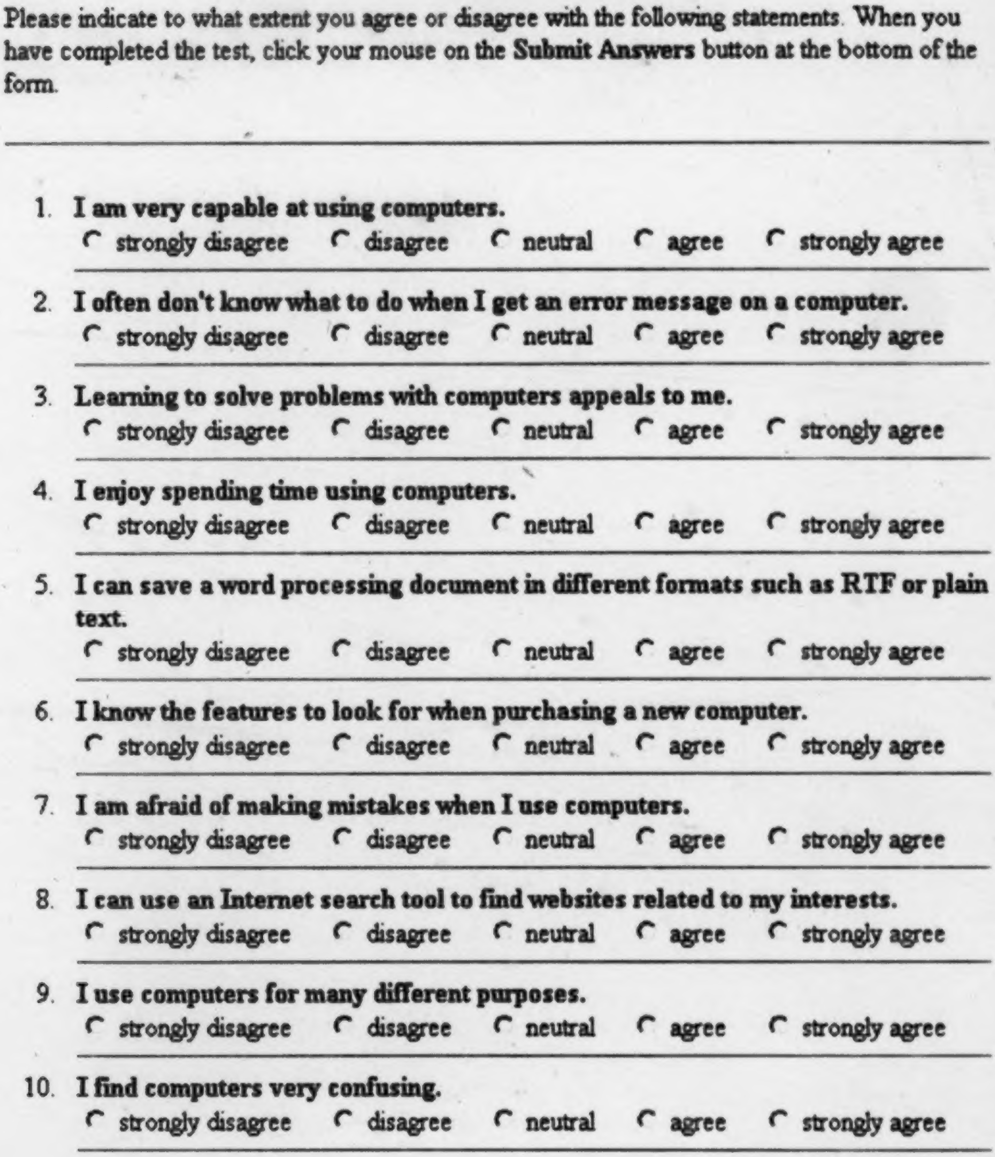
25. **What is your Minor subject?**

APPENDIX E:
ICT Literacy - Computer Attitudes Survey



Please indicate to what extent you agree or disagree with the following statements. When you have completed the test, click your mouse on the **Submit Answers** button at the bottom of the form.

---

1. **I am very capable at using computers.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
2. **I often don't know what to do when I get an error message on a computer.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
3. **Learning to solve problems with computers appeals to me.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
4. **I enjoy spending time using computers.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
5. **I can save a word processing document in different formats such as RTF or plain text.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
6. **I know the features to look for when purchasing a new computer.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
7. **I am afraid of making mistakes when I use computers.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
8. **I can use an Internet search tool to find websites related to my interests.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
9. **I use computers for many different purposes.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree
10. **I find computers very confusing.**
   ○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

11. **Computers can save people a lot of work.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

12. **In five years everyone will need to know how to operate a computer.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

13. **There is an overemphasis on computer technology in this society.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

14. **Putting computers in schools is too expensive.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

15. **Computers help prepare students for the future.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

16. **Computers are just as important to students as textbooks.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

17. **The Internet can be a useful tool in teaching.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

18. **Using technology in teaching should be optional.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

19. **Computer skills will be important in order to get a teaching job.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

20. **Computers will be very useful in my particular major or minor.**
○ strongly disagree ○ disagree ○ neutral ○ agree ○ strongly agree

Submit Answers

APPENDIX F:
ICT Literacy - Knowledge Test

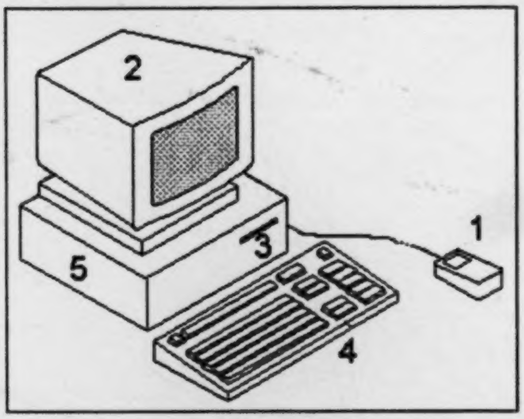
This is a test of your knowledge concerning Information and Communication Technology (ICT) terminology and concepts.

- Please answer these questions on your own and to the best of your ability.
- You should attempt every question.
- If you are not sure of the correct answer, please make your best guess.
- When you have completed the test, click your mouse on the **Submit Answers** button at the bottom of the form.

Section 1 - Computer Basics

---

1. **Match the 5 numbered areas of the diagram below with the most appropriate computer system component names.**



○ 1-Mouse, 2-Monitor, 3-Hard Drive, 4-Keyboard, 5-Control Panel

○ 1-Numeric Keypad, 2-Control Panel, 3-Hard Drive, 4-Monitor, 5-CPU

○ 1-Numeric Keypad, 2-Control Panel, 3-Floppy Drive, 4-Monitor, 5-Memory

○ 1-Mouse, 2-Control Panel, 3-SCSI Port, 4-Keyboard, 5-Memory

○ 1-Mouse, 2-Monitor, 3-Floppy Drive, 4-Keyboard, 5-CPU

2. **The common high-density 3.5" PC floppy disk has approximately how much storage space?**
    - ○ 100 Megabytes
    - ○ 100 Kilobytes
    - ○ 100 Gigabytes
    - ○ 1.4 Kilobytes
    - ○ 1.4 Megabytes

---

3. **What does GUI stand for?**
    - ○ General User Internet
    - ○ Graphical User Interface
    - ○ General User Interface
    - ○ Graphic Unit Interchange
    - ○ General Unit Interchange

---

4. **A GIGABYTE is approximately**
    - ○ One billion bytes
    - ○ One billion bits
    - ○ One million bytes
    - ○ One million bits
    - ○ One thousand bytes

Section 2 - Word Processing

---

1. **Which of the following are examples of word processing programs?**
    - ○ Word Perfect, FileMaker Pro, and Microsoft Word
    - ○ Microsoft Word, Word Perfect, and Eudora
    - ○ Adobe Acrobat, Word Perfect, and QuickTime Pro
    - ○ AppleWorks, Microsoft Works, and Microsoft Word
    - ○ Word Perfect, Adobe Premiere, and Microsoft Word

2. **What is the CLIPBOARD?**
   - ○ A utility which allows you to access clip art.
   - ○ A storage area for saving what was last copied or cut.
   - ○ A default document.
   - ○ Where text is put when you use the paste command.
   - ○ A document template.

---

3. **Symbols similar to the following are used in most word processors:** ≡ ≡ ≡ ≡
   What do the 4 symbols mean (from left to right)?
   - ○ Left, center, hanging, and even indentation.
   - ○ Left, center, right, and justify paragraph alignment.
   - ○ Left, center, right, and full page borders.
   - ○ Left, center, right, and even tabs.
   - ○ Left, center, right, and even indentation.

---

4. **A default FONT SIZE commonly used in word processors is**
   - ○ 12 point
   - ○ 1 point
   - ○ 24 point
   - ○ 1 mm
   - ○ 12 mm

Section 3 - Internet

---

1. **HTML is short for**
   - ○ HyperText Modem Language
   - ○ HyperText Markup Link
   - ○ HyperTerminal Modem Link
   - ○ HyperText Markup Language
   - ○ HyperTerminal Modem Language

2. **Which of the following is a correctly formatted email address?**
   - ○ http:\\www.company.com\email.htm
   - ○ http://www.company.com/email.htm
   - ○ somebody@company.com
   - ○ somebody@www/company/com
   - ○ C:\Program Files\email.exe

---

3. **What is the Netscape equivalent to Microsoft Internet Explorer Favorites?**
   - ○ History
   - ○ Channels
   - ○ Shortcuts
   - ○ Bookmarks
   - ○ Address Book

---

4. **What is TELNET?**
   - ○ A program which allows remote login to another computer over the Internet.
   - ○ A section of the Internet which uses standard telephone commmunication.
   - ○ A protocol for sending files from one computer to another over the Internet.
   - ○ Another name for the Internet.
   - ○ An Internet-accessible library catalog.

Section 4 - Digital Media

---

1. **What are the two most common image formats used on the World Wide Web?**
   - ○ JPEG and HTML
   - ○ BMP and GIF
   - ○ PNG and BMP
   - ○ PICT and PNG
   - ○ GIF and JPEG

2. **Which of the following statements about drawing and painting is true?**
   - ○ Painting and drawing are two terms which mean the same thing.
   - ○ Painted images usually require less memory than drawn images.
   - ○ Painting uses vector graphics while drawing uses bit maps.
   - ○ After enlarging, painted graphics look the same but drawn graphics become blurry.
   - ○ Painting uses patterns of dots to represent images while drawing uses geometrical formulas.

3. **Which of the following filename extensions indicate digital audio file formats?**
   - ○ PS, AU, and MOV
   - ○ AIFF, SIT and MP3
   - ○ MP3, WAV, and AIFF
   - ○ STK, SIT, and WAV
   - ○ WAV, AU, and SIT

4. **Which of the following filename extensions indicate digital video file formats?**
   - ○ AVI, VID, and ZIP
   - ○ MOV, JPEG, and AVI
   - ○ MPEG, JPEG, and AVI
   - ○ MOV, AVI, and MPEG
   - ○ MPEG, JPEG, and MOV

Section 5 - Electronic Presentations

1. **Which of the following programs' main use is creation of computer-based presentations?**
   - ○ HyperStudio and PowerPoint
   - ○ Word and Excel
   - ○ Eudora and Corel Gallery
   - ○ Lotus 1-2-3 and LView Pro
   - ○ Quattro Pro and Access

2. **What does MULTIMEDIA refer to?**
   - ○ The combination of text, sound, and pictures.
   - ○ A standard file format for computer-based presentations.
   - ○ The integration of two or more media such as text, graphics, animation, sound, or video.
   - ○ The process of using underlined text to link to different screen displays.
   - ○ A program for creating computer-based presentations.

---

3. **What is a TRANSITION?**
   - ○ Underlined text which jumps to a different screen display when you click on it.
   - ○ A visual effect used when changing the screen from one display to another.
   - ○ Continuously varying electrical signals.
   - ○ A microscopic component of a computer processor.
   - ○ A remote login to another computer over a network

---

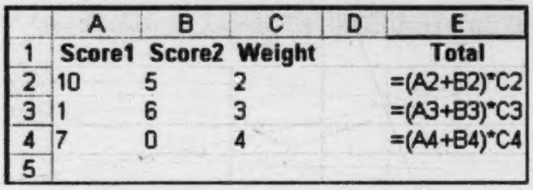
4. **What is HYPERTEXT?**
   - ○ A method for displaying text in which selecting a particular text item leads to a display of related information.
   - ○ A protocol for transmitting documents over the Internet.
   - ○ A text file which can be transmitted over a network.
   - ○ The integration of text with other media such as graphics, animation, sound, or video.
   - ○ A text file that has been compressed so that it takes up less space.

Section 6 - Spreadsheets

---

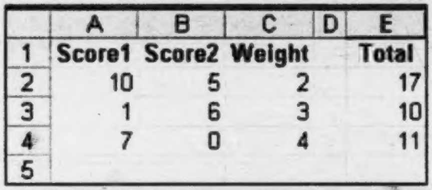
1. **To indicate a formula, a spreadsheet cell usually begins with**
   - ○ A colon (:)
   - ○ A single quote (')
   - ○ A double slash (//)
   - ○ An equal sign (=)
   - ○ A question mark (?)

2. **The following image represents a view of a spreadsheet with the formulas visible.**

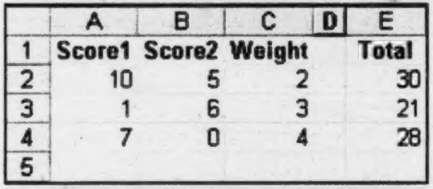


	A	B	C	D	E
1	Score1	Score2	Weight		Total
2	10	5	2		=(A2+B2)*C2
3	1	6	3		=(A3+B3)*C3
4	7	0	4		=(A4+B4)*C4
5					

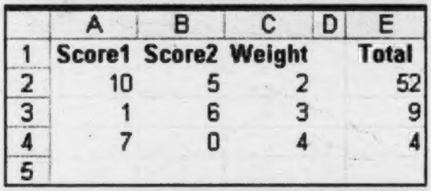
Which of the images below represents the same spreadsheet with the results visible?

○ 

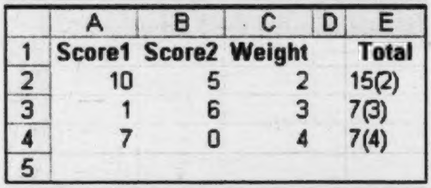
	A	B	C	D	E
1	Score1	Score2	Weight		Total
2	10	5	2		17
3	1	6	3		10
4	7	0	4		11
5					

○ 

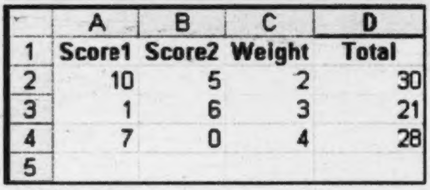
	A	B	C	D	E
1	Score1	Score2	Weight		Total
2	10	5	2		30
3	1	6	3		21
4	7	0	4		28
5					

○ 

	A	B	C	D	E
1	Score1	Score2	Weight		Total
2	10	5	2		52
3	1	6	3		9
4	7	0	4		4
5					

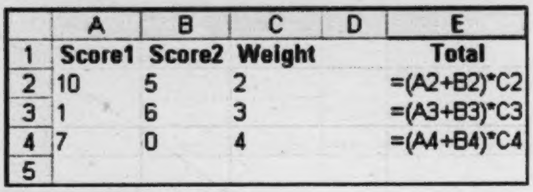
○ 

	A	B	C	D	E
1	Score1	Score2	Weight		Total
2	10	5	2		15(2)
3	1	6	3		7(3)
4	7	0	4		7(4)
5					

○ 

	A	B	C	D
1	Score1	Score2	Weight	Total
2	10	5	2	30
3	1	6	3	21
4	7	0	4	28
5				

3. **Which calculation would you place in the 5th row of the second column of the following spreadsheet to compute the average of the "Score2" values?**



	A	B	C	D	E
1	Score1	Score2	Weight		Total
2	10	5	2		=(A2+B2)*C2
3	1	6	3		=(A3+B3)*C3
4	7	0	4		=(A4+B4)*C4
5					

- ○ AVERAGE (2B + 4B)
- ○ (B2 : B4) / 3
- ○ AVERAGE (B2 : B4)
- ○ AVERAGE (B2 : B5)
- ○ (2B + 5B) / 3

4. **Cell B2 of a spreadsheet contains the formula A2 / A$5. If this formula was copied and pasted into cell D1, the resulting formula would be**

- ○ C1 / A$5
- ○ D2 / D$5
- ○ C1 / C$5
- ○ C1 / D$5
- ○ C2 /$C5

Section 7 - Databases

1. **Which of the following programs can be used to create related database tables?**

- ○ AppleWorks and Microsoft Works
- ○ Microsoft Works and Microsoft Access
- ○ AppleWorks and Microsoft Access
- ○ AppleWorks and FileMaker Pro
- ○ FileMaker Pro and Microsoft Access

2. **The following is a listing of all the records in a database table.**

Students			
ID Number	**Last Name**	**First Name**	**Address**
0111111	Smith	John	1111 - 11 St.
0222222	Jones	Alice	2222 - 222 Ave.
1234567	Gates	William	1 Microsoft Way
7777777	Brown	Mary	7777 - Whyte Ave.
9999999	Apple	Mac	9999 Power Drive

The records are sorted in ascending order based on the table's primary key. What is this key?

○ 9999999

○ ID Number

○ 0000000

○ 0111111

○ Last Name

---

3. **Using the same database table displayed in the previous question, indicate how many records and fields the table contains.**

○ 20 records, 5 fields

○ 6 records, 4 fields

○ 4 records, 5 fields

○ 5 records, 4 fields

○ 5 records, 20 fields

---

4. **In database terminology, RECORD and FIELD are equivalent respectively to**

○ File and Column

○ Query and Table

○ Row and Column

○ Table and Column

○ Row and Type

Submit Answers

APPENDIX G:
ICT Literacy - Performance Test

- Start of Practical Test (get files from the ICT research computer)
- End of Practical Test (submit completed files to the ICT research computer)

***** DO STEPS 1 - 3 AT THE START OF THE PRACTICAL TEST *****

In this test, you will be asked to do some practical tasks on your computer. Please proceed according to the steps indicated below. So that our research results can be as accurate as possible, please do Step 3 (i.e. the actual practical test itself) completely on your own. If necessary, you may ask for assistance with any of the other steps on this page, as they are part of the practical test setup and submission process, but not what we are scoring.

Step 1 - Obtain Working Files

Click on the appropriate link below to download the files you will need to work with during this test:

- **Macintosh version:** ICT12.sit
  This file is a compressed archive in the common Stuffit (.sit) file format for Macintosh systems.

- **Windows version:** ICT13.zip
  This file is a compressed archive in the common Zip (.zip) file format for Windows systems.

Notes:

- The Macintosh system in the campus lab is configured to automatically expand .sit files onto the desktop.
- If you are using the Windows system in the campus lab, save this archive onto your desktop, then right-click the archive and select the command 'Extract to folder ....' or launch WinZip, open the archive, and extract the files into a folder on the desktop.
- If you are doing this test in another location and do not understand how to expand this archive, please contact a TA or the researcher.
- If the compressed archive has been properly expanded a new folder named **ICT12** (for Macintosh) or **ICT13** (for Windows) should appear on the desktop and should contain several files and sub-folders.

Step 2 - Obtain Practical Test Question Printout

If you are doing this test during an on-campus lab session, your lab instructor can provide you with a printed copy of the practical test questions (look on Side 2 of the instruction sheet). If you are doing this test in another location, look in the folder retrieved in Step 1 and print the Microsoft Word document named **Practical.doc**.

Step 3 - Do the Test Activities

Hide (minimize) this browser window and proceed to do the practical tasks indicated on the printout you obtained in Step 2. Return to this window later, when you have completed the test. If you close this window, you will have to re-login again at the end of the test in order to submit your files to the research computer.

*** DO STEPS 4 - 6 AT THE END OF THE PRACTICAL TEST ***

Reminder ... ask for help with the following steps, if you are at all unsure of what is required. This is important, so that we correctly receive a copy of your completed work.

Step 4 - Rename Working Folder

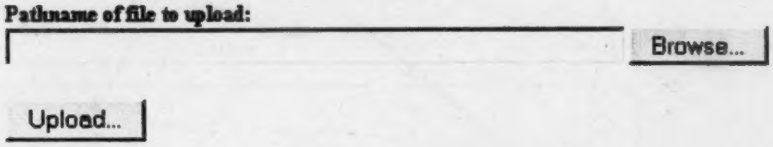
Rename the **ICT12** or **ICT13** working folder you used during the test. Make the new name of this folder **jedavies** (i.e. the ID you used when you logged into this test).

Step 5 - Compress Working Folder

Compress the **jedavies** folder (the one you used during the test and renamed as per the above step) i.e. Create a new archive named **jedavies.sit** or **jedavies.zip** containing the **jedavies** folder. On the Macintosh system in the lab, you can accomplish this by dragging the icon of the **jedavies** folder onto the **DropStuff** application program icon. On the Windows system in the lab, you can accomplish this by right clicking the icon of the **jedavies** folder and selecting the command **Add to jedavies.zip**.

Step 6 - Submit Compressed Archive

Click on the **Browse** button to indicate the location of the **jedavies.sit** or **jedavies.zip** file that you should have created in Step 5 (it should be on the desktop). Then, click on the **Upload** button to send this file to our server.



Practical.doc

General Instructions

- On your computer desktop is a folder (directory) named ICTx (where x = 12 or 13, version 12 is for Macintosh, version 13 is for Windows). It contains various files and sub-folders that must be used in the following tasks.
- All of the work that you do must be stored within the ICTx folder.
- Please do all of the tasks on your own and to the best of your ability.
- If you don't know how to do a certain task, just skip it and go on to the next one.

Part I

Perform the following operations on files and folders:

1) Change the name of the folder **B** to **Bat**
2) Change the name of the file **RenameMe.txt** to **Red.txt**
3) Move the file **MoveMe.txt** so that it is relocated inside of the folder **C**
4) Copy the file **CopyMe.txt** so that a second version of it is inside the folder **Q**
5) Delete the file **DeleteMe.txt**
6) Create a copy of the existing **Z** folder so that a second version of it is inside the **ICTx** folder. Note: The new folder should be named **Z copy** (on Macintosh) or **Copy of Z** (on Windows). Upper or lower case letters in the folder name do not matter.
7) Delete the folder **D**
8) Create a new plain text file, and into this file type: **the dog chased the cat**. Name the file **abc.txt**, and save it in the **ICTx** folder.

Part II

Open the Microsoft Word file named **Questions12.doc** or **Questions13.doc** which is located in the **ICTx** folder. This document contains a table with two columns – on the left are questions and on the right is a blank area in which to type your responses. The questions pertain to files in the **ICTx** folder and programs on your computer. When you are done entering your answers, please re-save the Word document.

Part III

Find the Microsoft Excel spreadsheet file named **SS12.xls** or **SS13.xls**. Open this file, make the changes listed below, then re-save the document:

1) Modify the text in cell **A1** so that it is displayed in a **bold, 18-point, Courier New** font.
2) **Merge & Center** the text in cell **A1** so that it spans **columns A to G**
3) In cell **E5** insert a formula which calculates the amount of **Tax** i.e. multiply the **Current Price** (column D) by the **Tax Rate (B11)**
4) Copy the formula in cell **E5** to cells **E6** through **E9**
5) In cell **F5** insert a formula which calculates the **Total Price** i.e. add up **Current Price** (column D) and **Tax** (column E)
6) Copy the formula in cell **F5** to cells **F6** through **F9**
7) Display the contents of cells **C5** to **F9** with a dollar sign and two decimal places e.g. **$ 999.99**
8) In cell **G5** insert a formula which displays the word **Sale** in G5 if the **Current Price** (column D) of this item is less than the **Regular Price** (column C) and otherwise leaves G5 empty.
9) Copy the formula in cell **G5** to cells **G6** through **G9**

- Please remember to re-save the spreadsheet file when you are finished the above tasks.
- When you have completed the Practical Test, return to your web browser to following the remaining steps regarding submitting your completed practical files to us. Ask your supervisor for assistance, if necessary.

Questions12.doc

Please type in answers to the following six questions. Enter your response in the box to the right of each question. The questions pertain to files in the **ICT12** folder and programs on your computer.

QUESTION	ANSWER
1. Launch the Macintosh **SimpleText** program. What is the 3rd command under SimpleText's **File** menu? (Your answer should be a word or short phrase)	
2. On what date was the file **Report.doc** last modified? (Your answer should look like: Dec 31, 1995)	
3. How many graphic (image) files are in the **A** folder? (Your answer should be an integer)	
4. What is the size (in bytes) of the file **A\Tokyo.jpg** ? (Your answer should be an integer)	
5. What is the height (in pixels) of the image **net.gif**? (Your answer should be an integer)	
6. Macintosh computers provide a file searching utility program that allows you to quickly list all of the files on your hard drive that contain particular characters in their filename, or were modified on a certain date. Launch this utility. What is the text that appears in the window title bar? i.e. the top center of the window. (Your answer should be a word or short phrase)	

Please remember to re-save this document when you are finished answering the above questions.

End of document

Version 12 (Macintosh)

APPENDIX H:
ICT Literacy - Sample Student Profile

Student Computer ID: sample

Computer Attitudes Survey
Knowledge Test
Performance Test

Computer Attitudes Survey

Fall 2000 Pre-Test
Date/Time Started: 9/12/2000 8:12:15 AM
Date/Time Submitted: 9/12/2000 8:14:03 AM

Your total score on this survey was: **84**.
The average score on this survey was: **70.2 (371 students)**.
The scores on this scale range from 0 to 100 with higher scores indicating greater confidence and more positive attitude concerning computers.

Knowledge Test

(multiple-choice questions)
Fall 2000 Pre-Test
Date/Time Started: 9/12/2000 8:14:07 AM
Date/Time Submitted: 9/12/2000 8:29:28 AM
Version: 3
The maximum score for each item is 1 point (1 means correct, 0 means incorrect).
Click on the underlined Question Numbers to review the question (correct answers are provided).

Section 1 - Computer Basics

Question #	Student Score	Average Score (362 Students)
Question 1	1	0.8
Question 2	1	0.6
Question 3	1	0.3
Question 4	1	0.5
Section Total	**4.0 / 4.0 = 100.0%**	**2.3 / 4 = 57.3%**

Section 2 - Word Processing

Question #	Student Score	Average Score (362 Students)
Question 1	1	0.7
Question 2	1	0.8
Question 3	1	0.5
Question 4	1	0.9
Section Total	**4.0 / 4.0 = 100.0%**	**2.9 / 4 = 72.4%**

Section 3 – Internet

Question #	Student Score	Average Score (362 Students)
Question 1	1	0.6
Question 2	1	0.8
Question 3	1	0.7
Question 4	1	0.5
Section Total	**4.0 / 4.0 = 100.0%**	**2.6 / 4 = 64.9%**

Section 4 - Digital Media

Question #	Student Score	Average Score (362 Students)
Question 1	1	0.6
Question 2	1	0.5
Question 3	1	0.6
Question 4	1	0.3
Section Total	**4.0 / 4.0 = 100.0%**	**2.0 / 4 = 50.1%**

Section 5 - Electronic Presentations

Question #	Student Score	Average Score (362 Students)
Question 1	1	0.9
Question 2	1	0.6
Question 3	1	0.6
Question 4	1	0.3
Section Total	**4.0 / 4.0 = 100.0%**	**2.4 / 4 = 61.0%**

Section 6 – Spreadsheets

Question #	Student Score	Average Score (362 Students)
Question 1	1	0.7
Question 2	1	0.8
Question 3	0	0.4
Question 4	0	0.2
Section Total	**2.0 / 4.0 = 50.0%**	**2.2 / 4 = 54.7%**

Section 7 – Databases

Question #	Student Score	Average Score (362 Students)
Question 1	1	0.2
Question 2	1	0.8
Question 3	1	0.6
Question 4	0	0.4
Section Total	**3.0 / 4.0 = 75.0%**	**1.9 / 4 = 47.5%**

Knowledge Test Total Score
Fall 2000 Pre-Test

Maximum Points	Student Score	Average Score (362 Students)
28	**25.0 / 28.0 = 89.3%**	**16.3 / 28.0 = 58.3%**

Performance Test

(practical tasks)

If your latest results are not displayed, try waiting 2 minutes, then press your browser Reload/Refresh button.

Performance Test

(practical tasks)
Fall 2000 Pre-Test
Date/Time Started: 9/12/2000 8:30:40 AM
Date/Time Completed: 9/12/2000 9:11:27 AM
Date/Time Marked: 9/12/2000 9:12:29 AM
Version: 7
Download Sample Correctly Completed Files

Section 1 - File/Folder Operations

Task #	Description	Max Points	Student Score	Average Score (372 Students)
1	Rename folder B to Big	4	4.0	3.2
2	Rename file RenameMe.txt to Cat.txt	4	4.0	3.3
3	Move file MoveMe.txt to folder A	4	4.0	3.7
4	Copy file CopyMe.txt to folder G	4	3.6	2.3
5	Delete file DeleteMe.txt	4	4.0	3.5
6	Create new folder EE in E folder	4	4.0	3.4
7	Delete folder D	4	4.0	3.5
8	Create New.txt plain text file	4	4.0	2.0
Section 1 Total Score		**32.0**	**31.6 / 32.0 = 98.8%**	**24.8 / 32.0 = 77.5%**

Section 2 - File/System Properties

Task #	Description	Max Points	Student Score	Average Score (372 Students)
1	Open and resave Questions.doc file	2	2.0	1.7
2	5th command under SimpleText File menu	5	5.0	2.8
3	Date Summary.doc last modified	5	1.7	2.2
4	How many graphic files in C folder	5	0.0	0.4
5	File size (bytes) of C\Hello.doc	5	2.5	1.1
6	Width (pixels) of telephone.gif	5	5.0	1.5
7	Window title of Find File (Sherlock) utility	5	5.0	0.7
Section 2 Total Score		**32.0**	**21.2 / 32.0 = 66.1%**	**10.3 / 32.0 = 32.3%**

Section 3 – Spreadsheet

Task #	Description	Max Points	Student Score	Average Score (372 Students)
1	Open and resave spreadsheet file SS7.xls	2	2.0	1.6
2	Cell A1 change font style to bold	1	0.0	0.7
3	Cell A1 change font face to Courier	1	0.0	0.7
4	Cell A1 change font size to 18	1	0.0	0.7
5	Cells A1-F1 set horizontal alignment to center	1	0.0	0.2
6	Merge cells A1-F1	1	0.0	0.2
7	Cell D5: formula (Retail Price * TaxRate)	4	4.0	1.5
8	Cell D6: copy D5 formula	0.5	0.5	0.2
9	Cell D7: copy D5 formula	0.5	0.5	0.2
10	Cell D8: copy D5 formula	0.5	0.5	0.2
11	Cell D9: copy D5 formula	0.5	0.5	0.2
12	Cell E5: formula (Retail Price + Tax)	3	3.0	1.3
13	Cell E6: copy E5 formula	0.5	0.5	0.2
14	Cell E7: copy E5 formula	0.5	0.5	0.2
15	Cell E8: copy E5 formula	0.5	0.5	0.2
16	Cell E9: copy E5 formula	0.5	0.5	0.2
17	Cell E11: formula (average of Column E)	3	3.0	0.8
18	Cells C5-E9 format numbers $ 999.99	2	2.0	0.6
19	Cell E11 format numbers $ 999.99	1	1.0	0.3
20	Cell F5: formula (Max of Column E)	6	2.5	0.1
21	Cell F6: copy F5 formula	0.5	0.0	0.0
22	Cell F7: copy F5 formula	0.5	0.0	0.0
23	Cell F8: copy F5 formula	0.5	0.0	0.0
24	Cell F9: copy F5 formula	0.5	0.0	0.0
Section 3 Total Score		**32.0**	**21.5 / 32.0 = 67.1%**	**10.0 / 32.0 = 31.4%**

Performance Test Total Score
Fall 2000 Pre-Test

Maximum Points	Student Score	Average Score (372 Students)
96	**74.2 / 96.0 = 77.3%**	**45.2 / 96.0 = 47.0%**

APPENDIX I:
Background Survey - Response Frequencies

(Fall 2000 / Winter 2001 Pretests, 701 participants)

1 Radio Do you have a home computer?

Response	Count	Percent	Response
0	1	0.1	No Response
1	612	87.3	Yes
2	88	12.6	No

2 Checkbox What type of home computer do you have? Check ALL applicable items.

Response	Count	Percent	Response
-1	89	12.7	No Response
0	22	3.1	Unsure
1	529	75.5	Windows
2	54	7.7	Macintosh
3	36	5.1	Other type
100	103	14.7	0 items selected
101	570	81.3	1 items selected
102	27	3.9	2 items selected
103	1	0.1	3 items selected

3 Radio What is the maximum speed of your home computer CPU?

Response	Count	Percent	Response
0	90	12.8	No Response
1	336	47.9	Not sure
2	8	1.1	Less than 100 MHz
3	40	5.7	100 - 199 MHz
4	41	5.8	200 - 299 MHz
5	51	7.3	300 - 399 MHz
6	43	6.1	400 - 499 MHz
7	92	13.1	500 MHz or more

4 Radio What is the approximate speed of your home Internet connection?

Response	Count	Percent	Response
0	92	13.1	No Response
1	160	22.8	Not sure
2	43	6.1	No Internet connection
3	44	6.3	Slower than 56K
4	160	22.8	56K
5	19	2.7	64K
6	10	1.4	128K
7	137	19.5	Cable Modem
8	30	4.3	ADSL
9	6	0.9	Other Fast Connection

5 Checkbox Which of the following hardware components are included in your home computer system? Check ALL applicable items.

Response	Count	Percent	Response
-1	90	12.8	No Response
0	2	0.3	None
1	112	16.0	Joystick
2	569	81.2	CD-ROM drive
3	106	15.1	Printer-black & white only
4	543	77.5	Speakers
5	189	27.0	Large hard drive (> 10 GigaBytes)
6	508	72.5	Printer-colour capable
7	237	33.8	Microphone
8	114	16.3	Zip, Jaz, or equivalent disk drive
9	182	26.0	Scanner
10	506	72.2	Modem
11	130	18.5	CD writer
12	50	7.1	Digital camera
13	74	10.6	LAN (Local Area Network)
14	10	1.4	Tape backup
15	60	8.6	Video digitizing card
100	92	13.1	0 items selected
101	9	1.3	1 items selected
102	20	2.9	2 items selected
103	56	8.0	3 items selected
104	117	16.7	4 items selected
105	137	19.5	5 items selected
106	98	14.0	6 items selected
107	66	9.4	7 items selected
108	42	6.0	8 items selected
109	36	5.1	9 items selected
110	15	2.1	10 items selected
111	3	0.4	11 items selected
112	5	0.7	12 items selected
113	4	0.6	13 items selected
114			14 items selected
115	1	0.1	15 items selected

6 Radio Do you have frequent access to a computer at your workplace or at another household?

Response	Count	Percent	Response
0	6	0.9	No Response
1	524	74.8	Yes
2	171	24.4	No

7 Integer In what year did you FIRST use a computer? (Enter a 4-digit number)

Response	Count	Percent	Response
0	8	1.1	0
1971	1	0.1	1971
1976	1	0.1	1976
1978	1	0.1	1978
1979	1	0.1	1979
1980	7	1.0	1980
1981	7	1.0	1981
1982	15	2.1	1982
1983	15	2.1	1983

1984	26	3.7	1984
1985	59	8.4	1985
1986	55	7.8	1986
1987	48	6.8	1987
1988	48	6.8	1988
1989	48	6.8	1989
1990	117	16.7	1990
1991	36	5.1	1991
1992	46	6.6	1992
1993	42	6.0	1993
1994	28	4.0	1994
1995	26	3.7	1995
1996	21	3.0	1996
1997	16	2.3	1997
1998	12	1.7	1998
1999	12	1.7	1999
2000	5	0.7	2000

8 Checkbox Which of the computer applications below have you used? Check ALL applicable items.

Response	**Count**	**Percent**	**Response**
-1	2	0.3	No Response
0	1	0.1	None
1	632	90.2	Games
2	457	65.2	Draw/Paint
3	674	96.1	Word Processing
4	671	95.7	Email (Electronic Mail)
5	272	38.8	Scanning
6	421	60.1	CD-ROM Reference Material
7	628	89.6	World Wide Web Browser
8	99	14.1	Digital Camera
9	204	29.1	Desktop Publishing
10	333	47.5	Telnet
11	41	5.8	Digital Audio Editing
12	156	22.3	Electronic Presentation
13	97	13.8	FTP (File Transfer Protocol)
14	34	4.9	Digital Video Editing
15	442	63.1	Spreadsheet
16	116	16.5	Online Conferencing
17	55	7.8	Graphic Animation
18	283	40.4	Database
19	75	10.7	Webpage Editor
20	94	13.4	File Compression
21	129	18.4	Computer Programming Language
22	93	13.3	Accounting/Tax Software
23	41	5.8	CAD (Computer-Aided Design)
100	3	0.4	0 items selected
101	4	0.6	1 items selected
102	11	1.6	2 items selected
103	29	4.1	3 items selected
104	38	5.4	4 items selected
105	59	8.4	5 items selected
106	89	12.7	6 items selected
107	81	11.6	7 items selected
108	71	10.1	8 items selected
109	62	8.8	9 items selected

110	64	9.1	10 items selected
111	57	8.1	11 items selected
112	32	4.6	12 items selected
113	23	3.3	13 items selected
114	20	2.9	14 items selected
115	13	1.9	15 items selected
116	12	1.7	16 items selected
117	8	1.1	17 items selected
118	5	0.7	18 items selected
119	5	0.7	19 items selected
120	2	0.3	20 items selected
121	5	0.7	21 items selected
122	7	1.0	22 items selected
123	1	0.1	23 items selected

9 Checkbox Which of the software below have you used? Check ALL applicable items.

Response	**Count**	**Percent**	**Response**
-1	3	0.4	No Response
0	4	0.6	None
1	632	90.2	Netscape
2	429	61.2	Microsoft Works
3	241	34.4	AppleWorks/ClarisWorks
4	202	28.8	WinZip
5	655	93.4	Microsoft Word
6	56	8.0	Claris Home Page
7	30	4.3	Aladdin/Stuffit Expander
8	274	39.1	Microsoft PowerPoint
9	36	5.1	FileMaker Pro
10	184	26.2	Eudora
11	444	63.3	Microsoft Excel
12	247	35.2	QuickTime Player
13	92	13.1	NCSA Telnet
14	538	76.7	Microsoft Internet Explorer
15	59	8.4	HyperStudio
16	108	15.4	WinQVT
17	255	36.4	Microsoft Outlook
18	110	15.7	Lotus 1-2-3
19	23	3.3	Fetch
20	110	15.7	Microsoft Access
21	541	77.2	WordPerfect
22	63	9.0	WS_FTP
23	48	6.8	Microsoft FrontPage
24	242	34.5	Corel Draw
25	280	39.9	Adobe Acrobat Reader
26	36	5.1	Microsoft PhotoDraw
27	47	6.7	Quattro Pro
28	139	19.8	Adobe PhotoShop
29	14	2.0	Microsoft Image Composer
30	9	1.3	Paradox
31	35	5.0	Adobe Illustrator
32	7	1.0	Microsoft GIF Animator
33	66	9.4	Corel Gallery
34	17	2.4	Adobe Premiere
35	138	19.7	PaintShopPro
36	16	2.3	Color It!
37	12	1.7	Adobe PageMill

38	9	1.3	Graphic Workshop Pro
39	25	3.6	GIFConverter
40	17	2.4	GraphicConverter
41	17	2.4	LView Pro
42	11	1.6	GIFBuilder
43	10	1.4	GIF Construction Set
100	7	1.0	0 items selected
101	4	0.6	1 items selected
102	21	3.0	2 items selected
103	32	4.6	3 items selected
104	38	5.4	4 items selected
105	50	7.1	5 items selected
106	72	10.3	6 items selected
107	64	9.1	7 items selected
108	71	10.1	8 items selected
109	48	6.8	9 items selected
110	61	8.7	10 items selected
111	45	6.4	11 items selected
112	43	6.1	12 items selected
113	26	3.7	13 items selected
114	23	3.3	14 items selected
115	22	3.1	15 items selected
116	13	1.9	16 items selected
117	12	1.7	17 items selected
118	7	1.0	18 items selected
119	9	1.3	19 items selected
120	8	1.1	20 items selected
121	11	1.6	21 items selected
122			22 items selected
123	2	0.3	23 items selected
124	2	0.3	24 items selected
125			25 items selected
126			26 items selected
127	3	0.4	27 items selected
128			28 items selected
129	3	0.4	29 items selected
130			30 items selected
131	2	0.3	31 items selected
132	1	0.1	32 items selected
133	1	0.1	33 items selected
134			34 items selected
135			35 items selected
136			36 items selected
137			37 items selected
138			38 items selected
139			39 items selected
140			40 items selected
141			41 items selected
142			42 items selected
143			43 items selected

10 Checkbox Which of the operating systems below have you used? Check ALL applicable items.

Response	Count	Percent	Response
-1	7	1.0	No Response
0	11	1.6	None
1	282	40.2	MS-DOS
2	301	42.9	Macintosh
3	638	91.0	Microsoft Windows 3.x / 95 / 98 / 2000
4	73	10.4	IBM OS/2
5	26	3.7	Unix
6	152	21.7	Microsoft Windows NT
100	18	2.6	0 items selected
101	243	34.7	1 items selected
102	212	30.2	2 items selected
103	133	19.0	3 items selected
104	73	10.4	4 items selected
105	18	2.6	5 items selected
106	4	0.6	6 items selected

11 Select In what grade did you FIRST use computers in SCHOOL?

Response	Count	Percent	Response
0	11	1.6	No Response
1	16	2.3	Kindergarten or earlier
2	28	4.0	1
3	32	4.6	2
4	47	6.7	3
5	104	14.8	4
6	66	9.4	5
7	70	10.0	6
8	89	12.7	7
9	44	6.3	8
10	27	3.9	9
11	37	5.3	10
12	18	2.6	11
13	50	7.1	12 or higher
14	62	8.8	Never

12 Checkbox In which of the following senior high school subjects were you required to use computers at some time?

Response	Count	Percent	Response
-1	12	1.7	No Response
0	169	24.1	None
1	22	3.1	Art
2	24	3.4	Physical Education
3	108	15.4	Mathematics
4	14	2.0	Music
5	49	7.0	Health
6	59	8.4	Chemistry
7	13	1.9	Drama
8	30	4.3	Industrial Arts
9	54	7.7	Physics
10	242	34.5	Social Studies
11	12	1.7	Home Economics
12	127	18.1	Biology
13	308	43.9	English Language Arts
14	133	19.0	Other Career & Technology Studies course

15	233	33.2	Computing Science
16	69	9.8	French Language Arts
17	67	9.6	Any other course
18	6	0.9	Other Science course
19	25	3.6	Other Humanities course
100	181	25.8	0 items selected
101	164	23.4	1 items selected
102	97	13.8	2 items selected
103	79	11.3	3 items selected
104	65	9.3	4 items selected
105	44	6.3	5 items selected
106	26	3.7	6 items selected
107	20	2.9	7 items selected
108	12	1.7	8 items selected
109	7	1.0	9 items selected
110	3	0.4	10 items selected
111	2	0.3	11 items selected
112			12 items selected
113	1	0.1	13 items selected
114			14 items selected
115			15 items selected
116			16 items selected
117			17 items selected
118			18 items selected
119			19 items selected

13 Integer In what year did you graduate from senior high school? (Enter a 4-digit number)

Response	Count	Percent	Response
0	4	0.6	0
1969	1	0.1	1969
1970	6	0.9	1970
1971	2	0.3	1971
1972	2	0.3	1972
1973	1	0.1	1973
1975	4	0.6	1975
1976	4	0.6	1976
1977	3	0.4	1977
1978	6	0.9	1978
1979	8	1.1	1979
1980	4	0.6	1980
1982	3	0.4	1982
1983	7	1.0	1983
1984	6	0.9	1984
1985	4	0.6	1985
1986	9	1.3	1986
1987	10	1.4	1987
1988	9	1.3	1988
1989	10	1.4	1989
1990	18	2.6	1990
1991	15	2.1	1991
1992	38	5.4	1992
1993	25	3.6	1993
1994	45	6.4	1994
1995	64	9.1	1995
1996	65	9.3	1996
1997	75	10.7	1997

1998	84	12.0	1998
1999	133	19.0	1999
2000	36	5.1	2000

14 Radio Where were you living during your final year of senior high school?

Response	Count	Percent	Response
0	10	1.4	No Response
1	341	48.6	University metro area (within 25 km of City 1)
2	17	2.4	City 2 metro area (within 25 km of City 2)
3	49	7.0	Other urban area in province
4	137	19.5	Rural area in province
5	98	14.0	Urban area outside of province
6	49	7.0	Rural area outside of province

15 Radio What is the highest level of schooling completed by either of your parents?

Response	Count	Percent	Response
0	11	1.6	No Response
1	8	1.1	less than grade 7
2	21	3.0	less than grade 10
3	51	7.3	some senior high school
4	122	17.4	senior high school diploma
5	142	20.3	less than 4 years post-secondary
6	207	29.5	4-year undergraduate degree
7	40	5.7	some graduate school
8	71	10.1	Masters degree
9	28	4.0	Doctoral degree

16 Radio Have you previously completed a post-secondary (for credit) course whose principal topic was related to computer technology?

Response	Count	Percent	Response
0	8	1.1	No Response
1	174	24.8	Yes
2	519	74.0	No

17 Radio Since you began post-secondary studies, have you taken any non-credit course, seminar or workshop whose principal topic was related to computer technology?

Response	Count	Percent	Response
0	10	1.4	No Response
1	70	10.0	Yes
2	621	88.6	No

18 Radio What computing course are you CURRENTLY registered in?

Response	Count	Percent	Response
0	10	1.4	No Response
1	660	94.2	Course 1
2	17	2.4	Course 2
3	2	0.3	Course 3
4			Course 4
5	4	0.6	other
6	8	1.1	none

19 Radio Gender

Response	Count	Percent	Response
0	14	2.0	No Response
1	474	67.6	Female
2	213	30.4	Male

20 Radio Year of university studies

Response	Count	Percent	Response
0	11	1.6	No Response
1	65	9.3	1
2	199	28.4	2
3	162	23.1	3
4	89	12.7	4
5	159	22.7	5 or higher
6	16	2.3	Unclassified/Other

21 Radio What Faculty are you registered in?

Response	Count	Percent	Response
0	14	2.0	No Response
1	468	66.8	Education
2	51	7.3	Physical Education & Recreation
3	32	4.6	Science
4	83	11.8	Arts
5	13	1.9	Business
6	8	1.1	Native Studies
7	7	1.0	Agriculture, Forestry & Home Ec.
8			Engineering
9	17	2.4	Open Studies
10	8	1.1	Other

22 Radio What degree program are you registered in?

Response	Count	Percent	Response
0	16	2.3	No Response
1	304	43.4	B.Ed.
2	155	22.1	B.Ed. (After Degree)
3	9	1.3	B.Ed. / B.A. (Native Studies)
4	11	1.6	B.Ed. / B.Sc. Combined
5	3	0.4	B. Ed. / B. Music Combined
6	48	6.8	B. Ed. / B. Physical Education Combined
7			B. Ed. / B.Sc. (Human Ecology) Combined
8	71	10.1	B.A.
9	33	4.7	B.Sc.
10	13	1.9	B.Com.
11	16	2.3	Open Studies
12	22	3.1	Other

23 Radio What education program route are you (or will you) be pursuing?

Response	Count	Percent	Response
0	17	2.4	No Response
1	275	39.2	Elementary Education
2	349	49.8	Secondary Education
3	11	1.6	Adult Education
4	2	0.3	Other Education Route
5	47	6.7	Not pursuing an Education degree

24 Select What is your Major subject?

Response	Count	Percent	Response
0	47	6.7	No Response
1	16	2.3	Art
2	47	6.7	Biological Sciences
3	11	1.6	CTS:Business & Technology
4	7	1.0	CTS:Human Ecology
5			CTS:Resources
6	7	1.0	CTS:Technology Studies
7	7	1.0	Drama
8	55	7.8	English Language Arts
9			Environmental Education
10	12	1.7	General Sciences
11	3	0.4	Mathematical Sciences
12	23	3.3	Mathematics
13	16	2.3	Music
14	91	13.0	Physical Education
15	10	1.4	Physical Sciences
16	10	1.4	Second Language (any)
17	85	12.1	Social Studies
18	79	11.3	Other
19	175	25.0	Not Applicable

25 Select What is your Minor subject?

Response	**Count**	**Percent**	**Response**
0	31	4.4	No Response
1	8	1.1	Art
2	24	3.4	Biological Sciences
3	4	0.6	CTS:Business & Technology
4	6	0.9	CTS:Human Ecology
5			CTS:Resources
6	4	0.6	CTS:Technology Studies
7	11	1.6	Drama
8	28	4.0	Early Childhood Education
9	37	5.3	Education Psychology
10	51	7.3	English Language Arts
11	6	0.9	Environmental Education
12	22	3.1	English as a Second Language
13	3	0.4	Fine Arts
14	24	3.4	General Sciences
15	4	0.6	Health Education
16	5	0.7	Instructional Technology
17	10	1.4	Intercultural/International Education
18	21	3.0	Language Arts
19	2	0.3	Mathematical Sciences
20	21	3.0	Mathematics
21	10	1.4	Mathematics/Science
22	11	1.6	Music
23	8	1.1	Native Education
24	39	5.6	Physical Education
25	28	4.0	Physical Sciences
26	5	0.7	Religious and Moral Education
27	31	4.4	Second Language
28	70	10.0	Social Studies
29	40	5.7	Special Education
30	42	6.0	Other
31	95	13.6	Not Applicable

APPENDIX J:
Attitude Survey - Response Frequencies

(Fall 2000/Winter 2001 Pretest, 686 participants)

1 I am very capable at using computers.

Score	Count	Percent	Response
	2	0.3	No Response
1	42	6.1	strongly disagree
2	136	19.8	disagree
3	200	29.2	neutral
4	253	36.9	agree
5	53	7.7	strongly agree
3.20	**Mean**		

2 I often don't know what to do when I get an error message on a computer.

*** Reversed Question ***

Score	Count	Percent	Response
	1	0.1	No Response
1	64	9.3	strongly agree
2	260	37.9	agree
3	177	25.8	neutral
4	158	23.0	disagree
5	26	3.8	strongly disagree
2.74	**Mean**		

3 Learning to solve problems with computers appeals to me.

Score	Count	Percent	Response
	2	0.3	No Response
1	40	5.8	strongly disagree
2	164	23.9	disagree
3	193	28.1	neutral
4	232	33.8	agree
5	55	8.0	strongly agree
3.14	**Mean**		

4 I enjoy spending time using computers.

Score	Count	Percent	Response
	1	0.1	No Response
1	20	2.9	strongly disagree
2	60	8.7	disagree
3	189	27.6	neutral
4	333	48.5	agree
5	83	12.1	strongly agree
3.58	**Mean**		

5 I can save a word processing document in different formats such as RTF or plain text.

Score	Count	Percent	Response
	2	0.3	No Response
1	108	15.7	strongly disagree
2	254	37.0	disagree
3	119	17.3	neutral
4	148	21.6	agree
5	55	8.0	strongly agree
2.69	**Mean**		

6 I know the features to look for when purchasing a new computer.

Score	Count	Percent	Response
	2	0.3	No Response
1	133	19.4	strongly disagree
2	205	29.9	disagree
3	148	21.6	neutral
4	156	22.7	agree
5	42	6.1	strongly agree
2.66	**Mean**		

7 I am afraid of making mistakes when I use computers.

*** Reversed Question ***

Score	Count	Percent	Response
	2	0.3	No Response
1	65	9.5	strongly agree
2	191	27.8	agree
3	124	18.1	neutral
4	239	34.8	disagree
5	65	9.5	strongly disagree
3.07	**Mean**		

8 I can use an Internet search tool to find websites related to my interests.

Score	Count	Percent	Response
	3	0.4	No Response
1	10	1.5	strongly disagree
2	19	2.8	disagree
3	33	4.8	neutral
4	352	51.3	agree
5	269	39.2	strongly agree
4.25	**Mean**		

9 I use computers for many different purposes.

Score	Count	Percent	Response
	1	0.1	No Response
1	11	1.6	strongly disagree
2	110	16.0	disagree
3	99	14.4	neutral
4	306	44.6	agree
5	159	23.2	strongly agree
3.72	**Mean**		

10 I find computers very confusing.

*** Reversed Question ***

Score	Count	Percent	Response
	1	0.1	No Response
1	47	6.9	strongly agree
2	153	22.3	agree
3	195	28.4	neutral
4	219	31.9	disagree
5	71	10.3	strongly disagree
3.17	**Mean**		

11 Computers can save people a lot of work.

Score	Count	Percent	Response
	1	0.1	No Response
1	5	0.7	strongly disagree
2	19	2.8	disagree
3	92	13.4	neutral
4	360	52.5	agree
5	209	30.5	strongly agree
4.09	**Mean**		

12 In five years everyone will need to know how to operate a computer.

Score	Count	Percent	Response
	1	0.1	No Response
1	6	0.9	strongly disagree
2	34	5.0	disagree
3	53	7.7	neutral
4	284	41.4	agree
5	308	44.9	strongly agree
4.25	**Mean**		

13 There is an overemphasis on computer technology in this society.

*** Reversed Question ***

Score	Count	Percent	Response
	3	0.4	No Response
1	67	9.8	strongly agree
2	166	24.2	agree
3	159	23.2	neutral
4	238	34.7	disagree
5	53	7.7	strongly disagree
3.06	**Mean**		

14 Putting computers in schools is too expensive.

*** Reversed Question ***

Score	Count	Percent	Response
	3	0.4	No Response
1	2	0.3	strongly agree
2	41	6.0	agree
3	141	20.6	neutral
4	351	51.2	disagree
5	148	21.6	strongly disagree
3.88	**Mean**		

15 Computers help prepare students for the future.

Score	Count	Percent	Response
	3	0.4	No Response
1	2	0.3	strongly disagree
2	7	1.0	disagree
3	28	4.1	neutral
4	356	51.9	agree
5	290	42.3	strongly agree
4.35	**Mean**		

16 Computers are just as important to students as textbooks.

Score	Count	Percent	Response
	3	0.4	No Response
1	14	2.0	strongly disagree
2	69	10.1	disagree
3	128	18.7	neutral
4	314	45.8	agree
5	158	23.0	strongly agree
3.78	**Mean**		

17 The Internet can be a useful tool in teaching.

Score	Count	Percent	Response
	4	0.6	No Response
1	2	0.3	strongly disagree
2	10	1.5	disagree
3	65	9.5	neutral
4	390	56.9	agree
5	215	31.3	strongly agree
4.18	**Mean**		

18 Using technology in teaching should be optional.

*** Reversed Question ***

Score	Count	Percent	Response
	3	0.4	No Response
1	29	4.2	strongly agree
2	149	21.7	agree
3	159	23.2	neutral
4	266	38.8	disagree
5	80	11.7	strongly disagree
3.32	**Mean**		

19 Computer skills will be important in order to get a teaching job.

Score	Count	Percent	Response
	3	0.4	No Response
1	3	0.4	strongly disagree
2	17	2.5	disagree
3	82	12.0	neutral
4	362	52.8	agree
5	219	31.9	strongly agree
4.14	**Mean**		

20 Computers will be very useful in my particular major or minor.

Score	Count	Percent	Response
	4	0.6	No Response
1	11	1.6	strongly disagree
2	60	8.7	disagree
3	192	28.0	neutral
4	278	40.5	agree
5	141	20.6	strongly agree
3.70	**Mean**		

APPENDIX K:
Knowledge Test - Response Frequencies (Fall)

(Fall 2000 Pretest, 364 participants)

Section 1

1 Match the 5 numbered areas of the diagram below with the most appropriate computer system component names.<br><br><img border="1" src="images/compsys.gif" width="298" height="234">

Correct Response: 5

ID	Count	Percent	Response Text
0	1	0.3	No Response
1	82	22.5	1-Mouse, 2-Monitor, 3-Hard Drive, 4-Keyboard, 5-Control Panel
2	1	0.3	1-Numeric Keypad, 2-Control Panel, 3-Hard Drive, 4-Monitor, 5-CPU
3			1-Numeric Keypad, 2-Control Panel, 3-Floppy Drive, 4-Monitor, 5-Memory
4	1	0.3	1-Mouse, 2-Control Panel, 3-SCSI Port, 4-Keyboard, 5-Memory
5	279	76.6	1-Mouse, 2-Monitor, 3-Floppy Drive, 4-Keyboard, 5-CPU

2 The original ZIP disk has approximately how much storage space?

Correct Response: 3

ID	Count	Percent	Response Text
0	12	3.3	No Response
1	26	7.1	1.4 Megabytes
2	54	14.8	64 Megabytes
3	234	64.3	100 Megabytes
4	28	7.7	1 Gigabyte
5	10	2.7	1.4 Gigabytes

3 What does GUI stand for?

Correct Response: 5

ID	Count	Percent	Response Text
0	9	2.5	No Response
1	28	7.7	Graphic Unit Interchange
2	18	4.9	General Unit Interchange
3	156	42.9	General User Interface
4	26	7.1	General User Internet
5	127	34.9	Graphical User Interface

4 A GIGABYTE is approximately

Correct Response: 2

ID	Count	Percent	Response Text
0	7	1.9	No Response
1	23	6.3	One billion bits
2	194	53.3	One billion bytes
3	107	29.4	One million bytes
4	8	2.2	One million bits
5	25	6.9	One thousand bytes

Section 2

1 What is the CLIPBOARD?

Correct Response: 2

ID	Count	Percent	Response Text
0	10	2.7	No Response
1	20	5.5	A utility which allows you to access clip art.
2	244	67.0	An area in memory for storing what was last copied or cut.
3	44	12.1	A document template.
4	40	11.0	Where text is put when you use the paste command.
5	6	1.6	A default document.

2 What is the difference between cutting and copying text?

Correct Response: 4

ID	Count	Percent	Response Text
0	3	0.8	No Response
1	26	7.1	You can only reuse text that is copied, not text that is cut.
2	1	0.3	There is no difference.
3	14	3.8	Text that is cut remains in its original location, while text that is copied is removed from its original location.
4	299	82.1	Text that is copied remains in its original location, while text that is cut is removed from its original location.
5	21	5.8	Cut clears the clipboard, while copy places text on the clipboard.

3 Symbols similar to the following are used in most word processors: <img src="images/wpalign.gif" width="96" height="24" alt="wpalign.gif (933 bytes)"><br> What do the 4 symbols mean (from left to right)?

Correct Response: 3

ID	Count	Percent	Response Text
0	1	0.3	No Response
1	3	0.8	Left, center, hanging, and even indentation.
2	80	22.0	Left, center, right, and full borders.
3	195	53.6	Left, center, right, and justify paragraph alignment.
4	28	7.7	Left, center, right, and even tabs.
5	57	15.7	Left, center, right, and even indentation.

4 Word processing is NOT a major function of which of the following programs?

Correct Response: 2

ID	Count	Percent	Response Text
0	3	0.8	No Response
1	3	0.8	Word Perfect
2	316	86.8	Adobe Premiere
3	18	4.9	AppleWorks
4	23	6.3	Microsoft Works
5	1	0.3	Microsoft Word

Section 3

1 FTP is short for

Correct Response: 5

ID	Count	Percent	Response Text
0	10	2.7	No Response
1	2	0.5	Font Translation Protocol
2	3	0.8	Frame Transfer Procedure
3	6	1.6	Font Translation Procedure
4	110	30.2	File Transfer Procedure
5	233	64.0	File Transfer Protocol

2 Which of the following is a correctly formatted email address?

Correct Response: 3

ID	Count	Percent	Response Text
0	3	0.8	No Response
1	11	3.0	http:\\www.company.com\email.htm
2	56	15.4	http://www.company.com/email.htm
3	292	80.2	somebody@company.com
4	2	0.5	somebody@www/company/com
5			C:\Program Files\email.exe

3 Which of the following is a correctly formatted URL?

Correct Response: 5

ID	Count	Percent	Response Text
0	5	1.4	No Response
1	26	7.1	homepage@company.com
2	10	2.7	homepage@www.company.com
3	14	3.8	C:\Program Files\Netscape\Communicator\Program\netscape.exe
4	56	15.4	http:\\www.company.com\products\homepage.htm
5	253	69.5	http://www.company.com/products/homepage.htm

4 What is TELNET?

Correct Response: 1

ID	Count	Percent	Response Text
0	11	3.0	No Response
1	168	46.2	A program which allows remote login to another computer over the Internet.
2	97	26.6	A section of the Internet which uses standard telephone commmunication.
3	39	10.7	A protocol for sending files from one computer to another over the Internet.
4	22	6.0	Another name for the Internet.
5	27	7.4	An Internet-accessible library catalog.

Section 4

1 **What are the two most common image formats used on the World Wide Web?**

Correct Response: 5

ID	Count	Percent	Response Text
0	16	4.4	No Response
1	56	15.4	JPEG and EPS
2	39	10.7	BMP and GIF
3	16	4.4	PNG and BMP
4	29	8.0	EPS and PNG
5	208	57.1	GIF and JPEG

2 **What is the difference between drawing and painting?**

Correct Response: 2

ID	Count	Percent	Response Text
0	19	5.2	No Response
1	19	5.2	Painted images usually require less memory than drawn images.
2	190	52.2	Drawing uses geometrical formulas to represent images, while painting uses patterns of dots.
3	59	16.2	Painting uses vector graphics and drawing uses bit maps.
4	6	1.6	After enlarging, painted graphics look the same but drawn graphics become blurry.
5	70	19.2	There is no difference.

3 **What are AIFF and WAV?**

Correct Response: 2

ID	Count	Percent	Response Text
0	26	7.1	No Response
1	33	9.1	Video file formats
2	229	62.9	Sound file formats
3	22	6.0	File compression techniques
4	11	3.0	Clip art formats
5	41	11.3	Photographic-quality image formats

4 **Which of the following are digital video file formats?**

Correct Response: 5

ID	Count	Percent	Response Text
0	25	6.9	No Response
1	39	10.7	AVI, VID, and ZIP
2	30	8.2	MOV, JPEG, and AVI
3	107	29.4	MPEG, JPEG, and AVI
4	57	15.7	MPEG, JPEG, and MOV
5	104	28.6	MOV, AVI, and MPEG

Section 5

1 **Which of the following programs' main use is creation of computer-based presentations?**

Correct Response: 2

ID	**Count**	**Percent**	**Response Text**
0	9	2.5	No Response
1	25	6.9	Word and Excel
2	312	85.7	HyperStudio and PowerPoint
3	5	1.4	Eudora and Corel Gallery
4	4	1.1	Lotus 1-2-3 and LView Pro
5	6	1.6	Quattro Pro and Access

2 **What does MULTIMEDIA refer to?**

Correct Response: 5

ID	**Count**	**Percent**	**Response Text**
0	9	2.5	No Response
1	10	2.7	A standard file format for computer-based presentations.
2	23	6.3	A program for creating computer-based presentations.
3	87	23.9	The combination of text, sound, and pictures.
4	2	0.5	The process of using underlined text to link to different screen displays.
5	229	62.9	The integration of two or more media such as text, graphics, animation, sound, or video.

3 **What is a TRANSITION?**

Correct Response: 1

ID	**Count**	**Percent**	**Response Text**
0	23	6.3	No Response
1	231	63.5	A visual effect used when changing the screen from one display to another.
2	52	14.3	Underlined text which jumps to a different screen display when you click on it.
3	14	3.8	Continuously varying electrical signals.
4	13	3.6	A microscopic component of a computer processor.
5	27	7.4	A remote login to another computer over a network

4 **What is HYPERTEXT?**

Correct Response: 1

ID	**Count**	**Percent**	**Response Text**
0	21	5.8	No Response
1	114	31.3	A method for displaying text in which selecting a special text item leads to a new screen.
2	32	8.8	A protocol for transmitting documents over the Internet.
3	58	15.9	A text file which can be transmitted over a network.
4	77	21.2	The integration of text with other media such as graphics, animation, sound, or video.
5	58	15.9	A text file that has been compressed so that it takes up less space.

Section 6

1 To indicate a formula, a spreadsheet cell usually begins with

Correct Response: 4

ID	Count	Percent	Response Text
0	16	4.4	No Response
1	38	10.4	A colon (:)
2	21	5.8	A single quote (')
3	19	5.2	A double slash (//)
4	262	72.0	An equal sign (=)
5	4	1.1	A question mark (?)

2 The following image represents a view of a spreadsheet with the formulas visible.<br><br><img border="1" src="images/ssq.gif" align="top" width="304" height="102"><br><br>Which of the images below represents the same spreadsheet with the results visible?

Correct Response: 3

ID	Count	Percent	Response Text
0	14	3.8	No Response
1	19	5.2	<img border="1" src="images/ssa.gif" width="245" height="103">
2	7	1.9	<img border="1" src="images/ssb.gif" width="245" height="103">
3	307	84.3	<img border="1" src="images/ssc.gif" width="246" height="103">
4	8	2.2	<img border="1" src="images/ssd.gif" width="245" height="102">
5	5	1.4	<img border="1" src="images/sse.gif" width="245" height="103">

3 Which calculation would you use in the 5th row of the first column of the following spreadsheet to compute the average of the "Score1" values?<br><br><img border="1" src="images/ssq.gif" align="top" width="304" height="102">

Correct Response: 3

ID	Count	Percent	Response Text
0	25	6.9	No Response
1	16	4.4	AVERAGE (2A + 4A)
2	126	34.6	(A2 : A4) / 3
3	150	41.2	AVERAGE (A2 : A4)
4	24	6.6	AVERAGE (A2 : A5)
5	18	4.9	(2A + 5A) / 3

4 Cell B2 of a spreadsheet contains the formula A2 / A$5. If this formula was copied and pasted into cell D1, the resulting formula would be

Correct Response: 3

ID	Count	Percent	Response Text
0	29	8.0	No Response
1	28	7.7	C1 / A$5
2	128	35.2	D2 / D$5
3	76	20.9	C1 / C$5
4	29	8.0	C1 / D$5
5	69	19.0	C2 / C$5

Section 7

1 **Which of the following programs can be used to create related database tables?**

Correct Response: 5

ID	Count	Percent	Response Text
0	25	6.9	No Response
1	117	32.1	AppleWorks and Microsoft Works
2	70	19.2	Microsoft Works and Microsoft Access
3	63	17.3	AppleWorks and Microsoft Access
4	19	5.2	AppleWorks and FileMaker Pro
5	65	17.9	FileMaker Pro and Microsoft Access

2 **The following is a listing of all the records in a database table.<br><br><img border="1" src="images/dbq.gif" width="439" height="168"><br><br>The records are sorted in ascending order based on the table's primary key. What is this key?**

Correct Response: 2

ID	Count	Percent	Response Text
0	14	3.8	No Response
1	6	1.6	9999999
2	274	75.3	ID Number
3	26	7.1	0000000
4	17	4.7	0111111
5	22	6.0	Last Name

3 **Using the same database table displayed in the previous question, indicate how many records and fields the table contains.**

Correct Response: 4

ID	Count	Percent	Response Text
0	20	5.5	No Response
1	51	14.0	20 records, 5 fields
2	7	1.9	6 records, 4 fields
3	25	6.9	4 records, 5 fields
4	220	60.4	5 records, 4 fields
5	36	9.9	5 records, 20 fields

4 **In database terminology FILE, ROW, and COLUMN are equivalent respectively to**

Correct Response: 3

ID	Count	Percent	Response Text
0	27	7.4	No Response
1	56	15.4	Query, Record, and Field
2	85	23.4	Table, Field, and Record
3	131	36.0	Table, Record, and Field
4	46	12.6	Query, Field, and Record
5	14	3.8	Table, Query, and Record

APPENDIX L:
Knowledge Test - Response Frequencies (Winter)

(Winter 2001 Pretest, 312 participants)

Section 1

1 **Match the 5 numbered areas of the diagram below with the most appropriate computer system component names.<br><br><img border="1" src="images/compsys.gif" width="298" height="234">**

Correct Response: 4

ID	Count	Percent	Response Text
0	1	0.3	No Response
1	1	0.3	1-Mouse, 2-Control Panel, 3-SCSI Port, 4-Keyboard, 5-Memory
2			1-Numeric Keypad, 2-Control Panel, 3-Hard Drive, 4-Monitor, 5-CPU
3	65	20.8	1-Mouse, 2-Monitor, 3-Hard Drive, 4-Keyboard, 5-Control Panel
4	244	78.2	1-Mouse, 2-Monitor, 3-Floppy Drive, 4-Keyboard, 5-CPU
5	1	0.3	1-Numeric Keypad, 2-Control Panel, 3-Floppy Drive, 4-Monitor, 5-Memory

2 **The common high-density 3.5" PC floppy disk has approximately how much storage**

Correct Response: 1

ID	Count	Percent	Response Text
0	7	2.2	No Response
1	158	50.6	1.4 Megabytes
2	27	8.7	64 Kilobytes
3	97	31.1	64 Megabytes
4	6	1.9	1024 Kilobytes
5	17	5.4	1.4 Kilobytes

3 **What does the term RAM most commonly refer to?**

Correct Response: 4

ID	Count	Percent	Response Text
0	3	1.0	No Response
1	14	4.5	Remote Analog Modem
2	8	2.6	Remote Active Monitoring
3	1	0.3	Real Audio Mixer
4	286	91.7	Random Access Memory
5			Removable Alternate Media

4 **A MEGABYTE is approximately**

Correct Response: 5

ID	Count	Percent	Response Text
0	6	1.9	No Response
1	8	2.6	One billion bits
2	45	14.4	One billion bytes
3	38	12.2	One thousand bytes
4	37	11.9	One million bits
5	178	57.1	One million bytes

Section 2

1 **Which of the following are examples of word processing programs?**

Correct Response: 2

ID	Count	Percent	Response Text
0	3	1.0	No Response
1	42	13.5	Word Perfect, FileMaker Pro, and Microsoft Word
2	157	50.3	AppleWorks, Microsoft Works, and Microsoft Word
3	5	1.6	Adobe Acrobat, Word Perfect, and QuickTime Pro
4	54	17.3	Microsoft Word, Eudora, and Word Perfect
5	51	16.3	Word Perfect, Adobe Premiere, and Microsoft Word

2 **What is the CLIPBOARD?**

Correct Response: 5

ID	Count	Percent	Response Text
0	6	1.9	No Response
1	15	4.8	A utility which allows you to access clip art.
2	7	2.2	A default document.
3	49	15.7	A document template.
4	61	19.6	Where text is put when you use the paste command.
5	174	55.8	An area in memory for storing what was last copied or cut.

3 **Symbols similar to the following are used in most word processors: <img src="images/wpsymb.gif" width="96" height="24" alt="wpsymb.gif (933 bytes)"><br> What do the 4 symbols mean (from left to right)?**

Correct Response: 2

ID	Count	Percent	Response Text
0	2	0.6	No Response
1	6	1.9	Left, center, hanging, and even indentation.
2	164	52.6	Left, center, right, and justify paragraph alignment.
3	52	16.7	Left, center, right, and full page borders.
4	26	8.3	Left, center, right, and even tabs.
5	62	19.9	Left, center, right, and even indentation.

4 **A default FONT SIZE commonly used in word processors is**

Correct Response: 1

ID	Count	Percent	Response Text
0	2	0.6	No Response
1	292	93.6	12 point
2	1	0.3	1 point
3	2	0.6	24 point
4	2	0.6	1 mm
5	13	4.2	12 mm

Section 3

1 FTP is short for

Correct Response: 3

ID	Count	Percent	Response Text
0	4	1.3	No Response
1	9	2.9	Font Translation Protocol
2	11	3.5	Frame Transfer Procedure
3	189	60.6	File Transfer Protocol
4	98	31.4	File Transfer Procedure
5	1	0.3	Font Translation Procedure

2 What is the Microsoft Internet Explorer equivalent to Netscape Bookmarks?

Correct Response: 3

ID	Count	Percent	Response Text
0	1	0.3	No Response
1	2	0.6	History
2	6	1.9	Channels
3	272	87.2	Favorites
4	14	4.5	Shortcuts
5	17	5.4	Links

3 Which of the following is a correctly formatted URL?

Correct Response: 1

ID	Count	Percent	Response Text
0	3	1.0	No Response
1	267	85.6	http://www.company.com/products/homepage.htm
2			homepage@www.company.com
3	9	2.9	C:\Program Files\Netscape\Communicator\Program\netscape.exe
4	29	9.3	http:\\www.company.com\products\homepage.htm
5	4	1.3	someone@company.com

4 What is TELNET?

Correct Response: 4

ID	Count	Percent	Response Text
0	6	1.9	No Response
1	7	2.2	Another name for the Internet.
2	101	32.4	A section of the Internet which uses standard telephone commmunication.
3	36	11.5	A protocol for sending files from one computer to another over the Internet.
4	115	36.9	A program which allows remote login to another computer over the Internet.
5	47	15.1	An Internet-accessible library catalog.

Section 4

1 **What are the two most common image formats used on the World Wide Web?**

Correct Response: 4

ID	Count	Percent	Response Text
0	14	4.5	No Response
1	27	8.7	JPEG and EPS
2	55	17.6	BMP and GIF
3	18	5.8	PNG and BMP
4	176	56.4	GIF and JPEG
5	22	7.1	EPS and PNG

2 **Which of the following statements about drawing and painting is true?**

Correct Response: 1

ID	Count	Percent	Response Text
0	17	5.4	No Response
1	146	46.8	Drawing uses geometrical formulas to represent images, while painting uses patterns of dots.
2	18	5.8	Painted images usually require less memory than drawn images.
3	72	23.1	Painting uses vector graphics and drawing uses bit maps.
4	23	7.4	After enlarging, painted graphics look the same but drawn graphics become blurry.
5	36	11.5	Painting and drawing are two terms which mean the same thing.

3 **Which of the following filename extensions indicate digital audio file formats?**

Correct Response: 2

ID	Count	Percent	Response Text
0	22	7.1	No Response
1	12	3.8	PS, AU, and MOV
2	218	69.9	MP3, WAV, and AIFF
3	28	9.0	AIFF, SIT and MP3
4	12	3.8	STK, SIT, and WAV
5	20	6.4	WAV, AU, and SIT

4 **Which of the following filename extensions indicate digital video file formats?**

Correct Response: 5

ID	Count	Percent	Response Text
0	22	7.1	No Response
1	39	12.5	AVI, VID, and ZIP
2	30	9.6	MOV, JPEG, and AVI
3	101	32.4	MPEG, JPEG, and AVI
4	37	11.9	MPEG, JPEG, and MOV
5	83	26.6	MOV, AVI, and MPEG

Section 5

1 **Which of the following programs' main use is creation of computer-based presentations?**

Correct Response: 3

ID	Count	Percent	Response Text
0	6	1.9	No Response
1	25	8.0	Word and Excel
2	4	1.3	Eudora and Corel Gallery
3	270	86.5	HyperStudio and PowerPoint
4	5	1.6	Lotus 1-2-3 and LView Pro
5	2	0.6	Quattro Pro and Access

2 **What does MULTIMEDIA refer to?**

Correct Response: 5

ID	Count	Percent	Response Text
0	5	1.6	No Response
1	9	2.9	A standard file format for computer-based presentations.
2	13	4.2	A program for creating computer-based presentations.
3	98	31.4	The combination of text, sound, and pictures.
4	3	1.0	The process of using underlined text to link to different screen displays.
5	184	59.0	The integration of two or more media such as text, graphics, animation, sound, or video.

3 **What is a TRANSITION?**

Correct Response: 3

ID	Count	Percent	Response Text
0	17	5.4	No Response
1	20	6.4	Continuously varying electrical signals.
2	43	13.8	Underlined text which jumps to a different screen display when you click on it.
3	202	64.7	A visual effect used when changing the screen from one display to another.
4	6	1.9	A microscopic component of a computer processor.
5	24	7.7	A remote login to another computer over a network

4 **What is HYPERTEXT?**

Correct Response: 1

ID	Count	Percent	Response Text
0	17	5.4	No Response
1	116	37.2	A method for displaying text in which selecting a particular text item leads to a display of related information.
2	39	12.5	A protocol for transmitting documents over the Internet.
3	40	12.8	A text file which can be transmitted over a network.
4	59	18.9	The integration of text with other media such as graphics, animation, sound, or video.
5	41	13.1	A text file that has been compressed so that it takes up less space.

Section 6

1 **To indicate a formula, a spreadsheet cell usually begins with**

Correct Response: 4

ID	Count	Percent	Response Text
0	10	3.2	No Response
1	36	11.5	A colon (:)
2	24	7.7	A single quote (')
3	16	5.1	A double slash (//)
4	223	71.5	An equal sign (=)
5	3	1.0	A question mark (?)

2 **The following image represents a view of a spreadsheet with the formulas visible.<br><br><img border="1" src="images/ssq.gif" align="top" width="304" height="102"><br><br>Which of the images below represents the same spreadsheet with the results visible?**

Correct Response: 2

ID	Count	Percent	Response Text
0	9	2.9	No Response
1	15	4.8	<img border="1" src="images/ssa.gif" width="245" height="103">
2	261	83.7	<img border="1" src="images/ssc.gif" width="246" height="103">
3	12	3.8	<img border="1" src="images/ssb.gif" width="245" height="103">
4	10	3.2	<img border="1" src="images/ssd.gif" width="245" height="102">
5	5	1.6	<img border="1" src="images/sse.gif" width="245" height="103">

3 **Which calculation would you place in the 5th row of the second column of the following spreadsheet to compute the average of the "Score2" values?<br><br><img border="1" src="images/ssq.gif" align="top" width="304" height="102">**

Correct Response: 3

ID	Count	Percent	Response Text
0	20	6.4	No Response
1	18	5.8	AVERAGE (2B + 4B)
2	99	31.7	(B2 : B4) / 3
3	124	39.7	AVERAGE (B2 : B4)
4	30	9.6	AVERAGE (B2 : B5)
5	21	6.7	(2B + 5B) / 3

4 **Cell B1 of a spreadsheet contains the formula A1 / A$5. If this formula was copied and pasted into cell E2, the resulting formula would be**

Correct Response: 2

ID	Count	Percent	Response Text
0	24	7.7	No Response
1	23	7.4	D2 / A$5
2	68	21.8	D2 / D$5
3	137	43.9	E2 / E$5
4	49	15.7	D1 / D$5
5	11	3.5	D2 / E$5

Section 7

1 Which of the following programs can be used to create related database tables?

Correct Response: 5

ID	**Count**	**Percent**	**Response Text**
0	20	6.4	No Response
1	76	24.4	AppleWorks and Microsoft Works
2	59	18.9	Microsoft Works and Microsoft Access
3	53	17.0	AppleWorks and Microsoft Access
4	17	5.4	AppleWorks and FileMaker Pro
5	87	27.9	FileMaker Pro and Microsoft Access

2 The following is a listing of all the records in a database table.<br><br><img border="1" src="images/dbq.gif" width="439" height="168"><br><br>The records are sorted in ascending order based on the table's primary key. What is this key?

Correct Response: 2

ID	**Count**	**Percent**	**Response Text**
0	11	3.5	No Response
1	3	1.0	9999999
2	232	74.4	ID Number
3	20	6.4	0000000
4	19	6.1	0111111
5	27	8.7	Last Name

3 Using the same database table displayed in the previous question, indicate how many records and fields the table contains.

Correct Response: 4

ID	**Count**	**Percent**	**Response Text**
0	13	4.2	No Response
1	33	10.6	20 records, 5 fields
2	8	2.6	6 records, 4 fields
3	22	7.1	4 records, 5 fields
4	214	68.6	5 records, 4 fields
5	22	7.1	5 records, 20 fields

4 In database terminology, RECORD and FIELD are equivalent respectively to

Correct Response: 3

ID	**Count**	**Percent**	**Response Text**
0	11	3.5	No Response
1	45	14.4	File and Column
2	7	2.2	Query and Table
3	224	71.8	Row and Column
4	10	3.2	Table and Column
5	15	4.8	Row and Type

APPENDIX M:
Performance Test - Response Frequencies (Fall)

(Fall 2000 Pretest, 372 participants)

Section	Task	Task Description	Incorrect		Partially-Correct		Correct	
1			N	%	N	%	N	%
	1	Rename folder B to Big	63	16.9	39	10.5	270	72.6
	2	Rename file RenameMe.txt to Cat.txt	44	11.8	39	10.5	289	77.7
	3	Move file MoveMe.txt to folder A	30	8.1	6	1.6	336	90.3
	4	Copy file CopyMe.txt to folder G	114	30.6	243	65.3	15	4.0
	5	Delete file DeleteMe.txt	45	12.1	3	0.8	324	87.1
	6	Create new folder EE in E folder	36	9.7	39	10.5	297	79.8
	7	Delete folder D	49	13.2	0	0.0	323	86.8
	8	Create New.txt plain text file	111	29.8	122	32.8	139	37.4

Section	Task	Task Description	Incorrect		Partially-Correct		Correct	
2			N	%	N	%	N	%
	1	Open and resave Questions.doc file	66	17.7	0	0.0	306	82.3
	2	5th command under SimpleText File	143	38.4	42	11.3	187	50.3
	3	Date Summary.doc last modified	190	51.1	32	8.6	150	40.3
	4	How many graphic files in C folder	343	92.2	0	0.0	29	7.8
	5	File size (bytes) of C\Tokyo.jpg	251	67.5	79	21.2	42	11.3
	6	Width (pixels) of telephone.gif	261	70.2	0	0.0	111	29.8
	7	Window title of Find File (Sherlock)	321	86.3	0	0.0	51	13.7

Section	Task	Task Description	Incorrect		Partially-Correct		Correct	
3			N	%	N	%	N	%
	1	Open and resave spreadsheet file	71	19.1	0	0.0	301	80.9
	2	Cell A1 change font style to bold	104	28.0	0	0.0	268	72.0
	3	Cell A1 change font face to Courier	115	30.9	0	0.0	257	69.1
	4	Cell A1 change font size to 18	99	26.6	0	0.0	273	73.4
	5	Cells A1-F1 set horizontal alignment	281	75.5	10	2.7	81	21.8
	6	Merge cells A1-F1	306	82.3	4	1.1	62	16.7
	7	Cell D5: formula (Retail Price * Tax	162	43.5	192	51.6	18	4.8
	8	Cell D6: copy D5 formula	196	52.7	159	42.7	17	4.6
	9	Cell D7: copy D5 formula	197	53.0	158	42.5	17	4.6
	10	Cell D8: copy D5 formula	198	53.2	157	42.2	17	4.6
	11	Cell D9: copy D5 formula	197	53.0	158	42.5	17	4.6
	12	Cell E5: formula (Retail Price + Tax)	186	50.0	70	18.8	116	31.2
	13	Cell E6: copy E5 formula	221	59.4	49	13.2	102	27.4
	14	Cell E7: copy E5 formula	228	61.3	43	11.6	101	27.2
	15	Cell E8: copy E5 formula	224	60.2	47	12.6	101	27.2
	16	Cell E9: copy E5 formula	223	59.9	48	12.9	101	27.2
	17	Cell E11: formula (average of Column	232	62.4	87	23.4	53	14.2
	18	Cells C5-E9 format numbers $ 999.99	226	60.8	53	14.2	93	25.0
	19	Cell E11 format numbers $ 999.99	277	74.5	3	0.8	92	24.7
	20	Cell F5: formula (Max of Column E)	352	94.6	20	5.4	0	0.0
	21	Cell F6: copy F5 formula	357	96.0	15	4.0	0	0.0
	22	Cell F7: copy F5 formula	356	95.7	16	4.3	0	0.0
	23	Cell F8: copy F5 formula	358	96.2	14	3.8	0	0.0
	24	Cell F9: copy F5 formula	357	96.0	15	4.0	0	0.0

APPENDIX N:
Performance Test - Response Frequencies (Winter)

Winter 2001 Pretest, 240 participants

Section	Task	Task Description	Incorrect		Partially-Correct		Correct	
1			N	%	N	%	N	%
	1	Rename folder B to Bat	37	15.4	11	4.6	192	80.0
	2	Rename file RenameMe.txt to Red.txt	33	13.8	13	5.4	194	80.8
	3	Move file MoveMe.txt to folder C	27	11.3	8	3.3	205	85.4
	4	Copy file CopyMe.txt to folder Q	70	29.2	147	61.3	23	9.6
	5	Delete file DeleteMe.txt	37	15.4	2	0.8	201	83.8
	6	Create a copy of folder Z named Z	67	27.9	168	70.0	5	2.1
	7	Delete folder D	37	15.4	4	1.7	199	82.9
	8	Create abc.txt plain text file	90	37.5	76	31.7	74	30.8

Section	Task	Task Description	Incorrect		Partially-Correct		Correct	
2			N	%	N	%	N	%
	1	Open and resave Questions10.doc file	48	20.0	0	0.0	192	80.0
	2	3rd command under SimpleText File	119	49.6	0	0.0	121	50.4
	3	Date Report.doc last modified	106	44.2	36	15.0	98	40.8
	4	How many graphic files in A folder	169	70.4	0	0.0	71	29.6
	5	File size (bytes) of A\Tokyo.jpg	138	57.5	37	15.4	65	27.1
	6	Height (in pixels) of net.gif	227	94.6	0	0.0	13	5.4
	7	Window title of file search utility	166	69.2	10	4.2	64	26.7

Section	Task	Task Description	Incorrect		Partially-Correct		Correct	
3			N	%	N	%	N	%
	1	Open and resave spreadsheet file	53	22.1	0	0.0	187	77.9
	2	Cell A1 change font style to bold	91	37.9	0	0.0	149	62.1
	3	Cell A1 change font face to Courier	91	37.9	0	0.0	149	62.1
	4	Cell A1 change font size to 18	83	34.6	0	0.0	157	65.4
	5	Cells A1-G1 set horizontal alignment	142	59.2	11	4.6	87	36.3
	6	Merge cells A1-G1	150	62.5	5	2.1	85	35.4
	7	Cell E5: formula (Current Price * Tax	113	47.1	101	42.1	26	10.8
	8	Cell E6: copy E5 formula	126	52.5	91	37.9	23	9.6
	9	Cell E7: copy E5 formula	127	52.9	89	37.1	24	10.0
	10	Cell E8: copy E5 formula	125	52.1	91	37.9	24	10.0
	11	Cell E9: copy E5 formula	126	52.5	90	37.5	24	10.0
	12	Cell F5: formula (Current Price +	132	55.0	30	12.5	78	32.5
	13	Cell F6: copy F5 formula	139	57.9	26	10.8	75	31.3
	14	Cell F7: copy F5 formula	140	58.3	24	10.0	76	31.7
	15	Cell F8: copy F5 formula	139	57.9	26	10.8	75	31.3
	16	Cell F9: copy F5 formula	137	57.1	27	11.3	76	31.7
	17	Cells C5-F9 format numbers $ 999.99	128	53.3	30	12.5	82	34.2
	18	Cell G5: formula (Is item on sale?)	212	88.3	13	5.4	15	6.3
	19	Cell G6: copy G5 formula	213	88.8	12	5.0	15	6.3
	20	Cell G7: copy G5 formula	214	89.2	11	4.6	15	6.3
	21	Cell G8: copy G5 formula	213	88.8	12	5.0	15	6.3
	22	Cell G9: copy G5 formula	214	89.2	11	4.6	15	6.3